EXHIBIT 85

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MICHIGAN
SOUTHERN DIVISION

In re Flint Water Cases	Civil Action No. 5:16-cv-10444-JEL-MKM (consolidated) Hon. Judith E. Levy Mag. Mona K. Majzoub
Elnora Carthan, et al. v. Governor Rick Snyder, et al.	Civil Action No. 5:16-cv-10444-JEL-MKM

DECLARATION OF PIERRE GOOVAERTS, Ph.D., IN SUPPORT OF PLAINTIFFS' MOTION FOR CLASS CERTIFICATION

I, Pierre Goovaerts, Ph.D., state and declare as follows:

I. INTRODUCTION

1. My name is Pierre Goovaerts. I am a resident of Jerome, Michigan. I am providing this Declaration in Support of Plaintiffs' Motion for Class Certification. I am legally competent to provide this Declaration.

2. I have been retained as a geostatistician and geographical information systems (GIS) expert on behalf of a putative subclass of children in the City of Flint who were exposed to, and ingested, Flint Water during the period of May 1, 2014 through January 5, 2016.

3. I have been asked to estimate the number of "potentially-exposed plaintiffs" for the city of Flint, using criteria to define the "potentially-exposed plaintiffs" provided in the declaration made by Dr. Howard Hu and summarized below.

4. I have also been asked to construct a database from publically available geospatial data regarding the location and other characteristics (e.g., built year, vacancy) of all the residential and commercial tax parcels in Flint in order to assist potential class members to determine whether they are part of the proposed "subclass of injured children", the criteria for which is provided in the declaration submitted by Dr. Howard Hu and summarized below. Specifically, I have been asked to construct a database of identified parcels to assist potential class members determine whether they are part of the following subclass definition comprised of children who were injured from lead in childhood, children who were injured from lead *in utero,* and children who were injured from lead through a combination of *in utero* and childhood exposure:

> The class is defined as children who, during the period from May 1, 2014 to January 5, 2016, were (a) in utero or between the ages of 0 to 10 years old, (b) lived in an identified residence or attended an identified school or day care, and (c) were exposed through ingestion to unfiltered Flint public water at such residence, school or day care for at least 14 days within a 90 day period.

II. QUALIFICATIONS

5. I am Chief Scientist at BioMedware, Inc., a company specializing in research in medical geography and environmental epidemiology coupled with the development of space-time information system software, located in Ann Arbor, Michigan. As my *Curriculum Vitae* (attached as Exhibit 1) reflects, in addition to my scientific position at BioMedware I currently have an academic appointment, courtesy Associate Professor, at the University of Florida, Soil and Water Sciences Department. Before that, I was on the faculty of the University of Michigan, Department of Civil and Environmental Engineering for five years. Prior to my appointment at the University of Michigan, I was a Senior Research Assistant with the National Fund for Scientific Research in Belgium (1993-1997).

6. I received my Ph.D. in Agricultural Engineering from the Catholic University of Louvain-la-Neuve (Belgium) and completed my Post-Doctoral studies as a Fulbright Scholar at Stanford University. At that time I also was the Firmin Van Brée Fellow of the Hoover foundation of the Belgian American Educational Foundation (1993). A more complete statement of my credentials is contained in my curriculum vitae, a copy of which is attached as Exhibit 1.

7. In terms of specific scientific expertise, I have 30 year experience in the development and implementation of geostatistical algorithms and I am now a

pioneer in the application of geostatistics to medical geography and environmental epidemiology. Since 2002 I have been awarded by NIH (NCI, NIEHS) five SBIR Phase I and II grants and two SBIR Phase I and II contracts to develop methods and software for the integration, visualization and space-time analysis of health outcomes and environmental data. I have received several scientific awards, such as the 1999 Andrei Borisovich Vistelius Research Award attributed by the International Association of Mathematical Geology for an original and outstanding contribution, as a young scientist, to the application of mathematics and informatics to the earth sciences, the 2013 Distinguished Lecturer Award, International Association of Mathematical Geology, and the 2016 Founder's Award in recognition for "substantial and lasting contributions to the foundations of spatial accuracy", International Spatial Accuracy Research Association (ISARA). Since 2009 I am the Associate Editor of the international journal, Mathematical Geosciences.

8. Since 2000, I have taught over 60 short courses to train graduate students and professionals (e.g., consultants, public health officials, agency employees) in the theory and application of Geostatistics to environmental and health sciences. These courses were organized in countries on all six continents (France, Switzerland, Portugal, Italy, Turkey, Australia, Niger, India, South Korea, China, Japan, Colombia, USA) and were attended by over 1,000

participants. These courses, combined with the 28 talks delivered in 2013 as Distinguished Lecturer of the International Association of Mathematical Geology, substantially increased the exposure of the scientific and professional community to the application of new geostatistical methodology in spatial epidemiology.

9. I have authored more than 160 referred papers in the field of theoretical and applied geostatistics and have written one of the most highly cited textbooks in the field of geostatistics[1]. I have also contributed to several encyclopedia on the topic of fate and transport of environmental contaminants[2], spatial uncertainty in medical geography[3], exposure reconstruction using space–time information technology[4], and geostatistical analysis[5].

10. As president of PGeostat, LLC, since 2003 I have acted as a consultant on numerous environmental projects dealing with the characterization of air, soil and water pollution and its impact on human health.

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[1] Goovaerts, P. 1997. *Geostatistics for Natural Resources Evaluation*. Oxford Univ. Press, New-York, 483 p. 4th printing in June 2005. Reference textbook used in many universities, including the Ph.D. program in Geostatistics at Stanford University. 4th most cited book in the geostatistical literature.

[2] Goovaerts, P. 2011. Fate and Transport: Geostatistics and Environmental Contaminants. In: Nriagu JO (ed.) *Encyclopedia of Environmental Health*, volume 2, pp. 701–714 Burlington: Elsevier.

[3] Goovaerts, P. 2015. Spatial Uncertainty in Medical Geography: A Geostatistical Perspective. In S. Shekhar and H. Xiong (eds) *Encyclopedia of GIS 2nd edition*. Springer-Verlag, Berlin, Germany. DOI 10.1007/978-3-319-23519-6_1302-2.

[4] Jacquez, G.M., Meliker, J.R., Rommel, R.R., and P.E. Goovaerts. 2019. Exposure reconstruction using space–time information technology. In: Nriagu JO (ed.) *Encyclopedia of Environmental Health*, volume 2, pp. 793–804 Burlington: Elsevier.

[5] Goovaerts, P. 2005. Geostatistical Analysis of Spatial Data, in 6.64 Geoinformatics, edited by Peter Atkinson, in *Encyclopedia of Life Support Systems* (EOLSS), Developed under the auspices of the UNESCO, Eolss Publishers, Oxford, UK, [http://www.eolss.net].

Clients include: 1) private companies, such as Altarum, GEI Consultants, General Dynamics Information Technology, Scoreboard, Stratus Consulting, Terumo Cardiovascular Systems, and XS, Inc, 2) national agencies, such as Environmental Protection Agency, New York City Department of Health and Mental Hygiene, Nuclear Regulatory Commission, and Tacoma-Pierce County Health Department, 3) international agencies, such as the French Institute for Radiological Protection and Nuclear Safety (IRSN), and the French National Institute for Industrial Environment and Risks (INERIS), 4) universities, such as Florida A&M University, Tufts University, University of Detroit Mercy, University of Louvain-la-Neuve (Belgium), University of Nebraska (Lincoln), University of Tennessee (Institute for Environmental Modeling), and the University of Michigan. I have also provided my expertise in two legal matters: 1) Review of report "*Statistical Analysis of Gas Leaks and Tree Decline and Mortality in Brookline, Hingham, Milton, and Saugus*" for Bowditch & Dewey LLP, and 2) Assist Stratus Consulting and Kanner & Whiteley, L.L.C. in developing estimates of the spatial extent and degree of oiling along Louisiana shorelines resulting from the Deepwater Horizon oil spill[6].

11. I have served on various expert review panels for the following

[6] Goovaerts, P., Wobus, C., Jones, R., and M. Rissing. 2016. Geospatial estimation of the impact of Deepwater Horizon Oil Spill on plant oiling along the Louisiana shorelines. *Journal of Environmental Management*, 180(15): 264-271.

agencies and international organizations: National Science Foundation, National Institutes of Health, Nuclear Regulatory Commission, National Environmental Research Council (UK), European Commission (reviewer for "*The Human Exposome Project: a toolbox for assessing and addressing the impact of environment on health"*), Swiss National Science Foundation, Romanian National Council for Scientific Research, Central Finance and Contracting Agency (CFCA) of the Republic of Latvia, and the "Fonds pour la Formation de Chercheurs et l'Aide à la Recherche" (FCAR), Quebec. I am also a reviewer for over 80 scientific journals.

12. I have been the major advisor of three doctoral students and have been a member of Ph.D. dissertation committees at the Universities of Santa Cruz (CA, 1994), Gent University (Belgium, 1997), the Catholic University of Louvain-la-Neuve (Belgium, 1997 & 2001), the Helsinki University of Technology (Finland, 1998), the French Institute of Petroleum (Paris, 1998), the Technical University of Lisbon (Portugal, 1999, 2016), the National Polytechnic Institute of Lorraine (Nancy, 2001), the University of Michigan (2002), the New University of Lisbon (Portugal, 2004), The University of Florida (2008), Edith Cowan University (Australia, 2011,2014), and the Aix-Marseille University (2014).

13. In terms of expertise specific to lead exposure, I conducted and published the first in-depth analysis[7] and time trend modeling of water lead levels recorded in Flint during a 10-month period following the return to Detroit water supply, contrasting the results obtained through two different sampling initiatives: (i) voluntary or homeowner-driven sampling whereby concerned citizens decided to acquire a testing kit and conduct sampling on their own, and (ii) State-controlled sampling where data were collected bi-weekly at selected sites after training of residents by technical teams (sentinel sites). The sampling bias associated with the sentinel monitoring network was analyzed in a subsequent paper[8], while a third paper[9] presented the first geospatial approach to predict, for each tax parcel in Flint, the likelihood that a home has a lead or galvanized service line based on neighboring field data (i.e., house inspection) and secondary information (i.e., construction year and city records). The issue of predicting water lead levels for each tax parcel across the City was tackled in two additional papers. First, I published the first application[10] of multivariate geostatistics to the modeling of the spatial distribution of water lead levels in a

[7] Goovaerts, P. 2017. The drinking water contamination crisis in Flint: Modeling temporal trends of lead level since returning to Detroit Water System. *Science of the Total Environment*, 581-582: 66-79.
[8] Goovaerts, P. 2017. Monitoring the aftermath of Flint drinking water contamination crisis: Another case of sampling bias. *Science of the Total Environment*, 590-591: 139-153.
[9] Goovaerts, P. 2017 How geostatistics can help you find lead and galvanized water service lines: The case of Flint, MI. *Science of the Total Environment*, 599-600: 1552-1563.
[10] Goovaerts, P. 2019 Geostatistical prediction of water lead levels in Flint, Michigan: a multivariate approach. *Science of the Total Environment*, 647: 1294-1304.

distribution network, combining city records on service line composition with water lead data collected through the State-administered sentinel monitoring program and the voluntary homeowner-driven approach. This approach was extended to the modeling of the space-time distribution of water lead levels in a second paper[11], demonstrating the benefit of geostatistics to fill gaps in sampled time series, i.e., predict water lead levels between sampling events. Four of these papers were published in Science of the Total Environment, a leading international scientific journal which is ranked 5th out of 117 journals in Environmental Science, Subcategory: Environmental Engineering[12]. This set of five peer-reviewed papers represents the most extensive analysis of the space-time distribution of water lead levels in Flint, Michigan. To the best of my knowledge, only one other study[13] with parcel-level predictions of water lead level was published for Flint. Using a data-driven approach Abernethy *et al.* (2016) developed an ensemble of predictive models to assess the risk of lead contamination in individual homes and neighborhoods in Flint. They trained these models using a wide range of data sources, including residential water

[11] Goovaerts, P. 2018. Flint drinking water crisis: a first attempt to model geostatistically the space-time distribution of water lead levels. In: B.S.D. Sagar, Q. Cheng, F. Agterberg (Eds.) Springer Handbook of Mathematical *Geosciences: Fifty Years of IAMG*, Chapter 14, pages 255-275.
[12] https://www.letpub.com/index.php?journalid=7412&page=journalapp&view=detail
[13] Abernethy, J., Anderson, C., Dai, C. et al., 2016. Flint water crisis: Data-driven risk assessment via residential water testing. arXiv preprint arXiv:1610.00580. https://arxiv.org/abs/1610.00580. (accessed May 9 2020).

tests, historical records, and city infrastructure data. Their analysis however ignored the spatial correlation among data and did not include a temporal component.

14. The principles and methodology I employed in forming my opinion are based on a review of and utilization of insights gained from peer-reviewed scientific literature that is relevant to the task at hand; the interpretation and utilization of publicly available data that are relevant to the task at hand and that I analyzed extensively in all my publications; and the reliance on the expert reports of colleagues (Dr. Cliff Weisel, Dr. Panos Georgopoulos, Dr. Howard Hu) involved in this matter who have undertaken rigorous assessments related to exposure to lead from the Flint Water Crisis as well as predicting the impact of such exposures on health outcomes.

15. One of the main characteristics of environmental data, such as lead concentrations in tap water, is their structured distribution in space and time, which reflects the impact of various factors operating at different spatial and temporal scales, such as housing characteristics (i.e., age of the house, composition of service lines), poverty level through its influence on maintenance of indoor plumbing, changes in water treatment and water pressure, or water age (the time it takes for the water to travel from the

treatment plant to the home plumbing system). Several studies[9,14] confirmed the presence of such spatial and temporal structures in water lead levels measured in Flint. Geostatistical spatio-temporal models[15] provide a probabilistic framework for data analysis and prediction that builds on the joint spatial and temporal dependence between observations to interpolate measurements to locations and times where no sample was collected. Geostatistics is now a standard generally-accepted methodology for environmental exposure assessment and reconstruction[2,4].

16. GIS (Geographical Information Systems) allows storage and integration of data from different sources (e.g., exposure information and health characteristics of populations) by geographic location[16]. It is a scientifically valid and generally accepted methodology to support exposure reconstruction[17]. For example, investigators in the Occupational and Environmental Epidemiology Branch of the National Cancer Institute implement GIS-based exposure assessments using georeferenced historical data resources and residential histories collected in studies of environmental hazards and cancer

[14] Abokifa, A.A., Katz, L., and L. Sela. 2020. Spatiotemporal trends of recovery from lead contamination in Flint, MI as revealed by crowdsourced water sampling. *Water Research*, 171: 115442, 10.1016/j.watres.2019.115442
[15] Montero, J.M., Fernandez-Aviles, G., and J. Mateu. 2015. *Spatial and spatio-temporal geostatistical modeling and kriging*. Wiley, New York
[16] National Research Council 2012. *Exposure Science in the 21st Century: A Vision and a Strategy*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13507.
[17] Nuckols, J., Ward, M., and L. Jarup. 2004. Using geographic information systems for exposure assessment in environmental epidemiology studies. *Environmental Health Perspectives*, 112: 1007–1115.

risk[18]. Their approaches include using GIS and spatial-analytic methods to characterize exposure to environmental risk factors, incorporating space-time-activity information in exposure assessments, and employing biological and environmental measurements for exposure validation. For the specific case of water lead levels, a recent study[19] applied GIS and a hydraulic model of distribution systems to test the influences of pipe material, pipe age, water age, and other water quality parameters on lead/copper leaching in Raleigh (NC).

17. Of critical importance when coupling GIS data and environmental/exposure models is the issue of error propagation, that is how the uncertainty in input data (e.g., water lead levels) translates into uncertainty about model outputs (e.g., blood lead levels). Methods for uncertainty propagation, such as Monte-Carlo analysis, are critical for estimating uncertainties associated with spatially-based policies in the area of environmental health, and in dealing effectively with risks[20].

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[18] National Research Council 2012. *Exposure Science in the 21st Century: A Vision and a Strategy*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13507.

[19] Wang, Z., Devine, H., Zhang, W. et al., 2014. Using a GIS and GIS-assisted water quality model to analyze the deterministic factors for Lead and Copper corrosion in drinking water distribution systems. *Journal of Environmental Engineering* 140, A4014004.

[20] Goovaerts, P., AvRuskin, G., Meliker, J., Slotnick, M., Jacquez, V, and J. Nriagu. 2004. Modeling uncertainty about pollutant concentration and human exposure using geostatistics and a space-time information system: Application to arsenic in groundwater of Southeast Michigan. In *Accuracy 2004*: Proceedings of the 6th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences.

III. STATEMENT OF OPINIONS

18. **Estimation of the size of the "potentially-exposed population" for the city of Flint.**

As noted earlier, the criteria for defining "potentially-exposed plaintiffs" are articulated in the declaration by Dr. Howard Hu and are as follows: all individuals who meet *all 3* of the following definitions and criteria:

i. Criterion 1: Eligible location of exposure: Having lived (or been in-utero) or attended a school or day care in the city of Flint for at least 90 days during the "eligible period of exposure".

ii. Criterion 2: Eligible age range: Having been 0-10 years old in-utero (conception to birth) for at least 90 days (the "eligible duration of exposure") in an "eligible location of exposure" during the "eligible period of exposure".

iii. Criterion 3: Eligible duration of exposure: Being willing to attest (by affidavit signed by a parent, guardian or primary caretaker), that: he/she drank or ate food prepared with unfiltered Flint tap water for at least 14 of the 90 days during the "eligible period of exposure".

Since the affidavit process specified in Criterion 3 has not yet been conducted, in the following paragraphs, I make the assumption that all Flint residents meet Criterion 3.

19. In my opinion and based on the approach described hereafter and validated using publically available census data, the number of children having been 0-10 years old or in-utero (conception to birth) for at least 90 days (the "eligible duration of exposure") in an "eligible location of exposure" during the "eligible period of exposure" is estimated to be 21,739 children. This number was calculated using the following procedure:

a. Use individual-level birth data provided by the Division for Vital Records & Health Statistics, Michigan Department of Health & Human Services. These data are geocoded at the census tract level and include both the month and year of birth.

b. Sum up all the viable births (i.e., no death within the first year) that took place between August 1, 2003 (child would have lived in the city of Flint for at least 90 days during the "eligible period of exposure" before turning 11 yo) and June 2016 (newborn would have been exposed in utero for at least 90 days). This calculation is based on the assumption that the number of children moving in and out of the City balance out, an assumption that is validated below.

The quantification of the size of the population of "potentially-exposed plaintiffs" from individual birth data is based on the assumption that the number of children moving in and out of the City balance out. To assess how realistic this way of computing the number of individuals falling within a given category of age is, a similar calculation was conducted using data from the 2010 census for the City of Flint. According to census data available at the census tract level, the total number of children under 5 yo is 9,036 while 8,187 individuals fall within the next age bracket (5 to 9 yo.), leading to a total of 17,223 children who were 0-9 years old in 2010. On the other hand, summing up all viable births that occurred between January 2001 and December 2009 yields a total of 17,399 children who were 0-9 years old in 2010. Both figures (17,223 vs 17,399) are extremely close, which validates the approach adopted here. Again, these estimates are made under the assumption that all Flint residents meet Criterion 3; thus, the true number of "potentially exposed plaintiffs" is likely to be lower.

20. **Creation of a database including all non-vacant residential and commercial tax parcels in Flint in order to assist "potentially-exposed plaintiffs" to determine whether they are part of the proposed "subclass of injured children", as defined in the declaration of Dr. Howard Hu (Criteria 4 to 6).**

In my opinion and based on data described in Section IV, this database will list 41,207 parcels, of which:

a. 40,834 parcels (99.09%) were built on or before 1986 (Criterion 4, see paragraph 20),

b. 42 parcels were built after 1986 but had at least one water sample obtained between 11/19/2014 and 10/13/16 that identified a level of lead above or equal to the minimum reporting level (MRL) of 1 ug/L (Criterion 5), and

c. 27 schools (e.g., community schools, charter schools, private schools, institutes), and 33 day care facilities were sampled for lead in tap water between 10/2/2015 and 8/10/2016; with all but one school and 26 day care facilities documenting, for at least one fixture, a level of lead above or equal to the minimum reporting limit (MRL) of 1 μg/L (Criterion 6),

The finest spatial resolution available for this database is the tax parcel level. A tax parcel, also referred to as real property or real estate, is created for assessment and taxation purposes. The parcel is usually defined by a legal description and, by following that description, the user should be able to locate the parcel on a tax parcel map. Tax parcels were chosen as units of analysis for several reasons: 1) each residential address can be linked to a tax parcel, 2) a large amount of publically available information is available for each parcel, such as housing characteristics (i.e., built year, composition of service line,

housing condition), parcel classification (e.g., residential, commercial, industrial), residential state equalized value, vacancy, and 3) each parcel is located within a census tract, which facilitates their combination with a large range of socio-demographic variables. It is noteworthy that a tax parcel can include multiple sampling sites, such as multiple rental units within an apartment complex or low-income housing developments. The 2015 tax parcel database for the City of Flint includes a total of 56,235 parcels[21]. Only the parcels that were classified as non-vacant residential or commercial (code 401 or 201) will be selected, resulting in a subset of 41,207 parcels.

IV. FACTS AND DATA CONSIDERED

21. The following information is available to support the creation of a computerized database related to the age of residential and commercial buildings in the city of Flint: the 2016 Parcels GIS layer (attribute "Year_built") provided by Flint GIS.

22. The following information is available to support the creation of a computerized database related to water lead levels in Flint residential and commercial properties. A database of 24,173 tap water lead samples, collected

[21] Data provided by Ken Koleda, GIS Director for Genesee County.

between 11/19/2014 and 10/13/2016, was assembled using the following sources of data:

a. 23,715 water lead level measurements recorded over the period 9/25/2015-10/13/2016[22].

b. 271 records collected by a Virginia Tech research team between 8/18/2015 and 9/4/2015.

c. DEQ City of Flint water sample results from 2014 and 2015 (187 data) were acquired through Freedom of Information Act (FOIA) request number 3072-16.

Records with an address that was incomplete or located outside the city of Flint were discarded. Data were then allocated to an individual tax parcel unit on the basis of their postal address.

23. The following information is available to support the creation of a computerized database related to water lead levels measured in Flint schools and daycare facilities:

a. Testing of water in Flint community schools conducted on October 2, 2015[23];

[22] Data downloaded from http://www.michigan.gov/flintwater (residential testing results)
[23] Government of Michigan. *Flint Community Schools Initial Screening Results (Oct. 2, 2015).* Available at https://www.michigan.gov/documents/deq/Flint_Community_Schools_Testing_Results__Initial_Screen_502382_7.pdf ; accessed on April 16, 2020.

b. The "Pre-Fixture Replacement", "Post-Fixture Replacement", or "Post-Filter Installation" testing of water in Flint schools conducted in 2016[24].

c. The "Post-Fixture Replacement" testing of water conducted of Flint daycares in 2016[25].

24. I have also reviewed the water sampling data collected by the Virginia Tech sampling team in August/September, 2015. (VATECH_00212274) I have removed the homes that were located outside of the City of Flint from that dataset. After removal of the homes located outside of Flint, all homes measured during the 2015 sampling period in Flint had at least one water sample with lead level above the instrumentational detection limit of 0.1 µg/L. Of the homes sampled during the crisis, 85% had lead levels above 1 µg/L or part per billion (ppb) in the first draw sample with 17% of those samples exceeding the USEPA action level of 15 µg/L. The 90th percentile water lead level was 26.8 µg/L and the maximum water lead level from first draw samples was 158.0 µg/L.

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[24] Government of Michigan. *2016 Schools Testing Results.* Available at https://www.michigan.gov/flintwater/0,6092,7-345-76292_76294_76297_77897-455439--,00.html ; accessed on April 16, 2020.

[25] Government of Michigan. *2016 Child/Day Care Testing Results*. Available at https://www.michigan.gov/flintwater/0,6092,7-345-76292_76294_76297_77898_77908---,00.html; accessed on May 23, 2020.

V. LIST OF PUBLICATIONS

25. This information is reported in my *Curriculum Vitae* (attached as Exhibit 1).

VI. LIST OF CASES

26. I have not provided any testimony at a trial or as deposition as an expert witness during the past four years.

VII. STATEMENT OF COMPENSATION PAID

27. PGeostat, LLC bills my time at an hourly billing rate of $175.00 and $350.00 per hour for deposition and trial testimony with reasonable expenses.

VIII. LIST OF REFERENCES

28. See Exhibit 3 attached.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and recollection.

Executed this 27th day of June, 2020, in Jerome, MI.

By: _____

Pierre Goovaerts, Ph.D.

EXHIBIT 1

Pierre Goovaerts

11487 Highland Hills Drive. Jerome, MI 49249
Email: goovaerts.pierre@gmail.com
Webpage: http://goovaerts.pierre.googlepages.com

Education:

- Catholic University of Louvain-la-Neuve (Belgium), *B.S., Agriculture Engineering with Highest Honors (summa cum laude)*, 1987.
- Catholic University of Louvain-la-Neuve (Belgium), *Ph.D., Agricultural Science with Highest Honors (summa cum laude with congratulations from the Jury)*, 1992.
- Stanford University, Dept. of Geological and Environmental Sciences, *Post-Doctoral Research Fellow*, January 1993 to December 1994.

Professional Experience:

- *Director*, Board of Lake LeAnn Property Owner's Association, June 2012 to June 2013.
- *Associate Editor*, Mathematical Geosciences, October 2009 to present.
- *Geostatistician*, Computer Sciences Corporation, July 2008 to present. Geostatistical characterization of contaminated sediments, estimation of volumes of sediments to be dredged, design of sampling schemes and remediation strategies.
- *Associate Professor (courtesy appointment)*, Soil and Water Science Department, University of Florida, Gainesville, January 2006 to present.
- *President*, PGeostat LLC., January 2003 to present.
- *Chief Scientist*, BioMedware Inc., November 2002 to present.
- *Assistant Professor*, Dept. of Civil and Environmental Engineering, The University of Michigan at Ann Arbor, September 1997 to October 2002.

  Teaching of classes in hydrology, statistics and probability, and geostatistics.
  Consultant for EPA, NRC, BioMedware, ScoreBoard, Terumo, ERIM, CDM, Universities of Nebraska, Cincinnati and Tennessee, Tufts University. Review reports and contribute to development and application of (geo)statistics to environmental sciences, remote sensing, health science, forestry, design of experiment, and agriculture.
- *Senior Research Assistant*, Dept. of Environmental Sciences and Land Management, Catholic University of Louvain-la-Neuve, Belgium, September 1993 to September 1997.
- *Research Assistant*, Dept. of Environmental Sciences and Land Management, Catholic University of Louvain-la-Neuve, Belgium, April 1989 to April 1993.

National and International Service:

- Secretary of the ISSS (International Soil Science Society) Working Group on Pedometrics (1998 to 2002), and elected chair for the period 2002-2003.
- Editor of the Newsletter of the ISSS (International Soil Science Society) Working Group on Pedometrics: 1998 to 2002.
- Member of the Editorial Board of the Oxford Univ. Press Series on Applied Geostatistics: 1998 to present.
- Member of the Education Committee of the IAMG, International Association for Mathematical Geology, (1999).
- Member of the Student Grant Commission of the IAMG (1999).
- Member of the Executive Committee of the North American Council on Geostatistics.
- Member of the Organizing and Scientific Committees of the 1st-6th European Conference on Geostatistics for Environmental Applications (1996, 1998, 2000, 2002, 2004, 2006).
- Member of the Scientific Committee of the Vth & VIth, VIIth International Geostatistical Congress (1996, 2000, 2004) and the 1999 Annual Conference of the International Association for Mathematical Geology.
- Member of the Science Advisory Board for the 4th, 5th & 6th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences.
- Member of PhD dissertation committees at the Universities of Santa Cruz (CA, 1994), Gent (Belgium, 1997), Louvain-la-Neuve (Belgium, 1997 & 2001), the Helsinki University of Technology (Finland, 1998), the French Institute of Petroleum (Paris, 1998), the Technical University of Lisbon (Lisbon, 1999), the National Polytechnic Institute of Lorraine (Nancy, 2001), the University of Michigan (2002), the New University of Lisbon (2004), The University of Florida (2008), Edith Cowan University (2011), the Aix-Marseille University (2014).
- Session chair: 1st, 2nd, 3rd, 5th, 6th, 7th & 8th European Conference on Geostatistics for Environmental Applications (Lisbon, 1996; Valencia, 1998; Avignon, 2000; Lausanne, 2004; Rhodes, 2006; Southampton, 2008; Gent, 2010), 3rd, 7th, 8th, 12th, 15th & 16th Annual Conferences of the International Association for Mathematical Geology (Barcelona, 1997; Cancun, 2001; Berlin, 2002; Liege, 2006; Stanford 2009; Budapest, 2010), Vth, VIIth and VIIIth International Geostatistical Congress (Sydney, 1996; Calgary, 2004; Santiago, 2008), 3rd, 4th & 6th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences (Quebec, 1998; Amsterdam, 2000; Portland, 2004), 3rd, 4th & 7th Pedometrics Conference (Sydney, 1999; Gent, 2001; Tubingen, 2007), Association of American Geographer's annual meeting (San Francisco, 2007; Boston, 2008; Las Vegas, 2009; Washington DC, 2010; Seattle WA, 2011), URISA's GIS in Public Health Conference (New Orleans, 2007), International Society for Exposure Assessment 2008 (Pasadena, 2008), Spatial Statistics (The Netherlands, 2011), Environmental Health (Brazil, 2011).
- Keynote speaker: 2nd Pedometrics Conference (Madison, 1997), Soil Quality Workshop (Edmonton, 1998), 5th Annual Conference of the International Association for Mathematical Geology

(Trondheim, 1999), 3rd Pedometrics Conference (Sydney, 1999), 6th, 9th and 11th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences (Portland, 2004; Leicester, 2010; Lansing, 2014), 6th European Conference on Geostatistics for Environmental Applications (Greece, 2006), 15th Annual Conferences of the International Association for Mathematical Geology (Stanford, 2009), VIII Iberian Geochemistry Conference / XVIII Geochemical Week (Castelo Branco, 2011), 9th International Symposium on Environmental Geochemistry (Aveiro, 2012), WALIS Forum (Perth, 2013), CRCSI (Cooperative Research Center for Spatial Information) Annual Conference (Christchurch, 2013).

Editorial Activities:

- External reviewer for the following agencies: NSF, NIH, NRC, National Environmental Research Council (UK), Natural Environment Research Council (UK), Swiss National Science Foundation, Romanian National Council for Scientific Research, and the "Fonds pour la Formation de Chercheurs et l'Aide a la Recherche" (FCAR), Quebec.
- Reviewer for 70 journals, including: Applied Geochemistry; Aquatic Living Resources; Australian Journal of Soil Research; Biology and Fertility of Soils; Biometrics; BMC Cancer; Canadian Journal of Fisheries and Aquatic Sciences; Canadian Journal of Forest Research; Canadian Journal of Remote Sensing; Canadian Journal of Statistics; Computational Geosciences; Computers and Electronics in Agriculture; Computer and Geosciences; Continental Shelf Research; Ecological Modeling; Ecology; Environmental and Ecological Statistics; Environmental Forensics Journal; Environmental Health; Environmental Management; Environmental Pollution; Environmental Science & Technology; Environmetrics; Epidemiology; European Journal of Population; European Journal of Soil Science; European Journal of Soil Biology; Forest Science; Geoderma; Geographical Analysis; Geographical and Environmental Modelling; Ground Water Monitoring & Remediation; Health and Place; Hydrological Sciences Journal; International Journal of Applied Earth Observation and Geoinformation; International Journal of Climatology; International Journal of Health Geographics; International Journal of Geographical Information Systems; International Journal of Geographical Information Science; International Journal of Geothermal Research and its Applications; Journal of Agriculture, Ecosytems and Environment; Journal of the American Water Resources Association; Journal of Applied Meteorology; Journal of Computational and Graphical Statistics; Journal of Contaminant Hydrology; Journal of Engineering Mathematics; Journal of Environmental Management; Journal of Environmental Quality; Journal of Geographical Information Sciences; Journal of Geographical Systems; Journal of Geophysical Research; Journal of Hazardous Materials; Journal of Health and Place; Journal of Hydrology; Journal of Hydrometeorology; Journal of Sedimentary Research; Journal of Water Resources Planning and Management; Letters in Spatial and Resource Sciences; Mathematical Geology; METRON -International Journal of Statistics; Photogrammetric Engineering and Remote Sensing; Plant and Soil; Precision Agriculture; Remote sensing of Environment; Soil and Tillage Research; Soil Science Society of America Journal; Soil Science; Soil and Sediment Contamination: an International Journal; Stochastic Environmental Research and Risk Assessment; Transaction in GIS; The Science of the Total Environment; Water, Air and Soil Pollution; Water Resources Research; Weed Research.

- Reviewer for the Consortium for Risk Evaluation with Stakeholder Participation, report entitled "*Defining background groundwater quality at the Savannah River Site*.".
- Editor of special issues in *Geoderma* (2001, 2007), *Journal of Geographical Systems* (2005), *Environmental and Ecological Statistics* (2007).

Short courses taught:

- 18 hr short course on Geostatistical Analysis of Environmental Data, Faculty of Agriculture (UCL, Belgium), April 28-30 1997, attendance: 12.
- 9 hr short course on Spatial Data Analysis, Ecole Polytechnique Federale de Lausanne (EPFL, Switzerland), February 12-13 1998, attendance: 15.
- 15 hr seminar on geostatistics, Snowden Mining Industry Consultants PtY Ltd (Perth), September 1999, attendance: 14.
- 10 hr short course on modeling of local uncertainty and stochastic simulation, Edith Cowan University (ECU, Perth), September 1999, attendance: 10.
- 9 hr short course on Spatial Data Analysis, Ecole Polytechnique Federale de Lausanne (EPFL, Switzerland), February 12-13 2000, attendance: 20.
- 8 hr short course "Geostatistical Analysis of Environmental Data", Institute for Statistics and Information Management of the New University of Lisbon, November 2002, attendance: 25.
- 1.5 day short course "Geostatistical Analysis of Spatial Data", The University of Michigan, March 12-13 2003, attendance: 15.
- 1.5 day short course "Exploratory Spatial Data Analysis", The University of Michigan, June 11-12 2003, attendance: 10.
- 5 day short course "Advanced Spatial Analysis Workshop for Public Health", Olympia (WA), August 11-15 2003, attendance: 10.
- 2 day short course "Introduction to Geostatistical Analysis of Spatial Data", The University of Michigan, 12/2-12/3 2003, 4/27-4/28 2004, 12/7-12/8 2004, 10/25-10/26 2005.
- 2 day short course "Advanced Geostatistical Analysis of Spatial Data", The University of Michigan, December 4-5 2003, April 29-30 2004, December 9-10 2004, October 26-27 2005.
- 5 day short course "Advanced Spatial Analysis Workshop for Public Health and Biosurveillance", Ann Arbor, August 24-27 2004, attendance: 10.
- 5 day short course "Advanced Spatial Analysis Workshop for Public Health and Biosurveillance", Ann Arbor, August 23-26 2005, attendance: 8.
- 4 day short course "Advanced Spatial Analysis Workshop for Public Health", in-house at Chicago Dept of Public Health, attendance: 16.
- 5 day short course "Geostatistical Analysis of Environmental Data", Florida (August 2005 to 2011, March 2006 to 2010, August 2012), India (April 2010, February 2011), Utah (April 2011), Portugal (May 2010, December 2010), attendance: 25 per course.

- 5 day short course "Introduction Course to Methods for Spatio-temporal Analysis of Exposure and Health Data", Geneva, February 13-17 2006, attendance: 10.
- 5 day short course "Introduction Course to Methods for Spatio-temporal Analysis of Exposure and Health Data", Paris, March 27-31 2006, attendance: 15.
- 4 day short course "Geostatistical Analysis of Environmental Data", in-house at US EPA Region 5, Chicago, February 2007, attendance: 13.
- 5 day short course "Introduction Course to Methods for Spatio-temporal Analysis of Exposure and Health Data", Niamey (Niger), December 6-10 2010, attendance: 20.
- 5 day short course "Geostatistical Analysis of Environmental Data", February 2011, Hyderabad (India), attendance: 15.
- 5 day short course "Geostatistical Analysis of Environmental Data", April 2011, Utah State University, Logan, attendance: 21.
- 5 day short course "Geostatistical Analysis of Environmental Data", August 2011, University of Florida, Gainesville, attendance: 13.
- 2 day short course "Application of Geostatistics to Environmental Epidemiology", Beijing (China), October 31-November 1 2011, attendance: 140.
- 2 day short course "Traitement de Données Spatialisées", INERIS, Verneuil-en-Halatte, October 17-18 1 2011, attendance: 15.
- 2 day short course "Application of Geostatistics to Environmental Epidemiology", Beijing (China), November 7-8 2011, attendance: 50.
- 5 day short course "Geostatistical Analysis of Environmental Data", February 2012, University of Evora, Portugal, attendance: 7.
- 5 day short course "Geostatistical Analysis of Environmental Data", May 2012, in-house at French Institute for Radiological Protection and Nuclear Safety (IRSN), Centre de Cadarache, attendance: 15.
- 5 day short course "Geostatistical Analysis of Environmental Data", December 2012, in-house at French Institute for Radiological Protection and Nuclear Safety (IRSN), Laboratoire d'Analyse Economique des Risques Nucléaires, Fontenay-aux-Roses, attendance: 10.
- 2 day short course "Geostatistics in Practice", May 2013, International School for Geoscience Resources (KIGAM, Korea), attendance: 27.
- 1 day short course "Geostatistics in Practice", May 2013, Tokyo University of Agriculture & Technology, attendance: 21.
- 2 day short course "Introduction to Environmental Health Geostatistics", November 2013, WALIS Forum (Perth, Australia), attendance: 20.
- 3 day short course "Environmental Geostatistics", July 2014, International School for Geoscience Resources (KIGAM, Korea), attendance: 28.
- 3 day short course "Introduction to Environmental Health Geostatistics", September 2014, Universidad Nacional de Colombia (Bogota, Colombia), attendance: 22.

- 3 day short course "Introduction to Environmental Geostatistics", October 2014, University of Caldas (Manizales, Colombia), attendance: 18.

Consulting activities (PGeostat, LLC)

For the last 13 years, I have acted as a consultant for various companies and agencies. My duties ranged from reviewing report on (geo)statistical analysis of environmental data to the development of new methodologies and customized programs for performing such analysis. Here is the list of current and past projects in which I have been involved, sorted by client names:

1. Altarum (formerly ERIM, Environmental Research Institute of Michigan)
   Development of methodology and corresponding computer program to conduct Monte-Carlo analysis allowing the estimation of errors in total carbon emissions from Alaskan wildfires (2005).

2. CDM
   My collaboration with CDM relates to the geostatistical treatment of data collected within EPA Pilot Study Analysis of the Kalamazoo River Superfund Site (2002).

3. CRESP (Consortium for Risk Evaluation with Stakeholder Participation)
   Review of the Technical report CCL/CRESP TR01-1 entitled "*Defining Background Groundwater Quality at the Savannah River Site*" (2001).

4. Computer Sciences Corporation
   Geostatistical characterization of contaminated sediments, estimation of volumes of sediments to be dredged, design of sampling schemes and remediation strategies. Review of Quality Assurance Project Plans (QAPP) for numerous sampling, characterization and remediation designs involving sites throughout the Great Lakes region.

5. Eastern Research Group, Inc
   External Peer review of the EPA's draft Report entitled "*Levels of Polychlorinated Dibenzodioxins, Polychlorinated Dibenzofurans, PCBs and Mercury in Rural Soils of the U.S.*" (2006).

6. Fields Groups, USEPA Region 5
   Review of the Report entitled "*A Geostatistical Assessment of Metals in Passaic River Sediment*", and additional analysis (2002).

7. French Institute for Radiological Protection and Nuclear Safety (IRSN)
   Accidents at nuclear power plants can lead to the contamination of vast territories and the substantial loss of agricultural productions, depending on various factors, such as land-cover around the plant or meteorological conditions at the time of the accident. IRSN asked PGeostat to conduct a preliminary probabilistic assessment of the agricultural consequences of an accident occurring at a French nuclear power plant.

8. French National Institute for Industrial Environment and Risks (INERIS)
   Support technique et encadrement scientifique pour la thématique d'analyse des relations spatiales entre données socioéconomiques, environnementales et sanitaires menée par

l'INERIS dans le cadre du programme DRC33.

9. New York City Department of Health and Mental Hygiene
   Preparation of a series of data sets for testing syndromic surveillance methods. Data sets had to be based on observed NYC emergency department data from 2004–2012 and include a combination of outbreak types, duration, season and magnitude. Simulated outbreaks covering the following five different syndromes needed to be inserted into NYC emergency department data (January 1, 2010–December 31, 2011): Diarrhea, vomit, fever, respiratory, and influenza-like illness (ILI). Development of an interface that enables NYC DOHMSH to generate new simulated outbreaks as needed.

10. Scoreboard
    Development of new geostatistical tools for the analysis and extrapolation of cellular signal data (1999-2000).

11. Stratus Consulting
    Assist Stratus Consulting in developing estimates of the spatial extent and degree of oiling along Louisiana shorelines resulting from the Deepwater Horizon oil spill.

12. Tacoma-Pierce County Health Department
    As part of the Tacoma Smelter Plume project, there have been a number of studies looking at soil contamination from the Asarco smelter. A significant amount of soil sampling data has been collected over a very large area. The different studies had different objectives, and so sampling methodology differed between studies, and thus the results are not perfectly comparable. The objective of this contract is for the Geostatistician consultant to: 1) develop a revised mapping methodology-protocol to incorporate both wind rose information and field data in the geostatistical mapping of arsenic concentration estimates and the probability of exceeding specific arsenic levels, 2) estimate the proportion of residential parcels exceeding specific arsenic thresholds at the block group level, and 3) develop power curves for various composite sampling strategies. The results of this project will be used to design a residential sampling and remediation program.

13. Terumo Cardiovascular Systems
    Design of experiments to assess the risks of failure of medical units and confidence levels under various scenarios (2002).

14. Thomas Richards
    Geostatistical evaluation of soil arsenic background level for a former commercial property, followed by a 3D modeling of the spatial distribution of soil lead and arsenic concentrations and delineation of areas that exceed the clean up level.

15. Tufts University
    SERDP project entitled " *Development of Assessment Tools for Evaluation of the Benefits of DNAPL Source Zone Treatment*"(2004-2006).
    The primary objective of the research is to develop and evaluate a suite of geostatistical

and modeling tools that can be utilized by site managers to: (1) predict and monitor plume development following DNAPL source zone treatment and (2) assess the cost/benefit trade-off in the selection of source zone remediation technology.

16. University of Louvain-la-Neuve, Belgium
    The overall objective of the project is to map the spatial distribution of 43 different soil pollutants (organic and inorganic) over the entire Walloon region (16,844 km^2) using data collected during several sampling campaigns, models of atmospheric depositions in urban areas, information on soil type and landuse. My main duties involve the development and application of advanced geostatistical techniques to detect spatial outliers and combine all these sources of information in the high-resolution mapping (500 m spacing) of soil pollution.

17. University of Nebraska, Lincoln
    USDA project entitled "*Thematic Soil Mapping and Crop-Based Strategies for Site-Specific Management*" (2003-3004).
    The overall objective of the project is to increase the efficiency of site-specific management of primary plant nutrients and other soil properties and thereby increase the profitability of farming and decrease negative environmental impact. My main duties involve the development of advanced geostatistical techniques for soil mapping at high spatial resolution, accounting for multiple sources of secondary information such as digital elevation model or thematic maps.

18. University of Tennessee, Institute for Environmental Modeling
    NRC project entitled "*Bayesian Subsurface Radiological Surveying and Analysis*".
    This project aims to add new capabilities to SADA (Spatial Analysis and Decision Assistance) software, mainly (1) the incorporation of prior (soft) knowledge on the spatial distribution of contaminants in the characterization of contaminated sites, (2) the automatic modeling of patterns of spatial variability, and (3) the optimization of 3D sampling designs.

19. University of Michigan, Ann Arbor
    UM project entitled "Dioxin Exposure Study" (http://www.sph.umich.edu/dioxin/).
    Elevated levels of dioxins have been found in the soil of the Tittabawassee River flood plain and nearby areas. Beginning in the fall of 2004, the University of Michigan is conducting a two-year study to find out whether the elevated levels of dioxins in the soil in the city of Midland, and in the Tittabawassee River flood plain between Midland and Saginaw, have also caused elevated levels of dioxins in residents' bodies. My main duties involve the geostatistical incorporation of field and atmospheric deposition data from the incinerator for modeling the spatial distribution of soil dioxin in Midland.

20. University of Michigan, Ann Arbor
    UM project entitled "Multi-Ethnic Study of Atherosclerosis".
    This study aims to investigate relationships between exposure to ambient air pollution and cardiovascular morbidity and mortality. My main duties involve the development of a space-time geostatistical approach for estimating air pollutant concentrations at addresses of patients participating to the study (2005).

21. XS, Inc., North Carolina

    Written and oral review of XS' AgVeritas product methodology to analyze spatially-reference data in the area of precision agriculture.

Grants and contracts with BioMedware

1. NIH SBIR Phase I; Geostatistical software for health and exposure analysis; 1/1/04-6/30/04; $99,889; PI.
2. NIH SBIR Phase I; Geostatistical software for detection of cancers; 9/1/04-2/30/05; $99,911; PI.
3. NIH SBIR Phase II; Simulation algorithms for spatial pattern recognition; 1/1/05-12/31/06; $998,063; PI.
4. NIH SBIR Phase II; Geostatistical software for health and exposure analysis; 9/1/05-8/31/07; $749,449; PI.
5. NIH SBIR Phase II; Geostatistical software for the space-time analysis of health disparities; 9/1/06-8/31/08; $717,614; PI.
6. NIH SBIR Phase I; Geostatistical software for the analysis of individual-level epidemiologic data; 9/1/07-2/30/08; $95,538; PI.
7. NIH contract; Automated pattern recognition in satellite imagery; 9/1/07-2/30/08; $149,999; co-PI.
8. NIH SBIR Phase I; Geostatistical software for the boundary analysis of cancer maps; 7/1/08-6/30/08; $99,979; PI.
9. NIH contract; Automated pattern recognition in satellite imagery; 9/1/09-8/31/11; $750,000; PI.
10. NIH SBIR Phase II; Geostatistical software for the analysis of individual-level epidemiologic data; 7/1/09-6/30/11; $816,386; PI.
11. NIH SBIR Phase I; Three-dimensional visualization, interactive analysis and contextual mapping of space-time cancer data; 11/1/10-10/31/11; $143,421; PI.
12. NIH R21; A geostatistical framework for the multi-scale boundary analysis of space-time trends in health outcomes; 12/1/12-11/30/14; $275,000; PI.
13. Pipeline Research Council International; Non-destructive pipeline stress detection using geostatistical pattern recognition analysis of magnetic flux leakage data; 1/1/13-12/31/14; $250,000; PI.
14. NIH SBIR Phase I; Geostatistical software for space-time interpolation and uncertainty modeling; 9/1/13-8/31/14; $183,478; PI.
15. NIH SBIR Contract Phase I; METRIC Software to Measure Cancer Health Environment; 9/12/14-5/11/15; $199,947; PI.

Grants and contracts at U of M

1. NSF; Propagation of Uncertainty in the Field Extrapolation of Laboratory Measurements: Application to Dioxin Contaminated Sediments; 9/1/99-8/31/02; $250,000; PI (Dr. P. Adriaens, co-PI); 1 GSRA supported.
2. EPA/DOD; Bayesian Approach to UXO Site Characterization with Incorporation of Geophysical Information; 1/1/01-12/31/02; $142,000; subcontractor for Sandia National Laboratories, 1 GSRA supported.
3. OVPR; Educational Program for Spatial Analysis/GIS; 9/1/00-8/31/01; $221,000; $0, collaborator (PIs: D. Brown, J.D. Nuystuen, E.D. Rothman).
4. OVPR; Initiating Research in Spatial Analysis of Society-Environment Interactions in Southeastern Michigan; 9/1/00-8/31/01; $277,000; $0, collaborator (PIs: D. Brown, R.W. Marans, G.R. Smith, M.L. Wilson).
5. NASA; Developing Land Cover Scenarios in Metropolitan and Non-metropolitan Michigan, USA: a Stochastic Simulation Approach; 9/1/01-8/31/04; $360,000; $160,000; co-PI (Dr. D. Brown, PI), 1 GSRA supported.
6. SERDP; Development of Assessment Tools for Evaluation of the Benefits of DNAPL Source Zone Treatment; 5/1/02-5/1/05; $895,913; co-PI (Dr. L. Abriola, PI), 2 GSRA supported.

Honors and awards received:

- Award for the best paper published in "Mathematical Geology", 1993.
- Firmin Van Brée Fellow of the Hoover foundation of the Belgian American Educational Foundation, 1993.
- Fulbright Research Scholarship, Stanford University, CA, 1993.
- Recipient of the 1999 Andrei Borisovich Vistelius Research Award attributed by the International Association of Mathematical Geology for an original and outstanding contribution, as a young scientist, to the application of mathematics and informatics to the earth sciences.
- Award for the best paper in Pedometrics published in 2000.
- 2013 Distinguished Lecturer Award, International Association of Mathematical Geology.

Publications

A recent scientometric analysis of geostatistics over the period 1967-2005 (Zhou *et al*., 2007 Scientometric analysis of geostatistics using multivariate methods. *Scientometrics*, DOI 10.1007/s11192-007-1798-5) identified Dr. Goovaerts as one of the most prolific and highly cited authors (largest annual citation per publication, ACPP) in the field. Google scholar h-index for 2014 is 41, while the i-10 index (number of publications with at least 10 citations) is 108.

Books

1. Jacquez, G.M., Goovaerts, P., Kaufmann, A. and R. Rommel. 2014. *SpaceStat 4.0 User Manual: Software for the Space-Time Analysis of Dynamic Complex Systems*, 04/2014; Edition: Fourth Edition, Publisher: BioMedware.

2. Goovaerts, P. 1997. *Geostatistics for Natural Resources Evaluation*. Oxford Univ. Press, New-York, 483 p. 4th printing in June 2005. Reference textbook used in many universities, including the Ph.D. program in Geostatistics at Stanford University. 4th most cited book in the geostatistical literature (http://www.pedometrics.org/pm/?p=49).

Refereed Journals

1. Goovaerts, P. and G. Glass. 2014. Geostatistical modeling of the spatial distribution of soil Arsenic around a smelter. *Journal of the Japanese Society of Soil Physics*, in press.

2. Goovaerts, P. 2014. Geostatistics - A common link between medical geography, mathematical geology and medical geology. *Danie Krige Commemorative Volume of the Journal of the Southern African Institute of Mining and Metallurgy*, **114**, 605-613.

3. Xiao, F., Tan, F., Goovaerts, P., Adunlin, G., Ali, A., Huang, Y. and C.K. Gwede. 2014. Factors associated with time-to-treatment of prostate cancer in Florida. *Journal of Health Care for the Poor and Underserved*, **24**, 132-146.

4. Goovaerts, P. 2013. Analysis of geographical disparities in temporal trends of health outcomes using space-time joinpoint regression. *Journal of Applied Earth Observation and Geoinformation*, **22**, 75-85.

5. Xiao, F., Tan, F., Goovaerts, P., Ali, A., Adunlin, G., Gwede, C.K. and Y. Huang. 2013. Multilevel factors associated with overall mortality for men diagnosed with prostate cancer in Florida. *American Journal of Men's Health*, doi: 10.1177/1557988313512862.

6. Xiao, F., Tan, F., Goovaerts, P., Adunlin, G., Ali, A., Huang, Y. and C.K. Gwede. 2013. Construction of a comorbidity index for prostate cancer patients linking state cancer registry with inpatient and outpatient data. *Journal of Registry Management*, **40**(4), 159-164.

7. Xiao, F., Tan, F., Goovaerts, P., Adunlin, G., Ali, A., Gwede, C.K. and Y. Huang. 2013. Use of treatment information from a State central cancer Registry in prostate cancer research. *Journal of Registry Management*, **40**(3), 127-130.

8. Zapata-Rios, X., Rivero, R.G., Naja, G.M. and P. Goovaerts. 2013. Response to Comments on "Spatial and temporal phosphorus distribution changes in a large wetland ecosystem" by X. Zapata-Rios et al, *Water Resources Research*, doi: 10.1002/wrcr.20160

9. Goovaerts, P. 2012. Geostatistical analysis of health data with different levels of spatial aggregation. *Spatial and Spatio-temporal Epidemiology*, **3**(1), 83-92.

10. Goovaerts, P., and H. Xiao. 2012. The impact of place and time on the proportion of late-stage diagnosis: The case of prostate cancer in Florida, 1981-2007. *Spatial and Spatio-temporal Epidemiology*, **3**, 243-253.

11. Baluja, J., Diago, M.P., Goovaerts, P. and J. Tardaguila. 2012. Assessment of the spatial variability of grape anthocyanins using a fluorescence sensor. Relationships with vine vigour and yield. *Precision Agriculture*, **13**, 457-472.

12. Baluja, J., Diago, M.P., Goovaerts, P. and J. Tardaguila. 2012. Spatio-temporal dynamics of grape anthocyanin accumulation in a Tempranillo vineyard monitored by proximal sensing. *Australian Journal of Grape and Wine Research*, **18**(2), 173-182.

13. Kerry, R., Goovaerts, P., Rawlins, B.G. and B.P. Marchant. 2012. Disaggregation of legacy soil data using area to point kriging for mapping soil organic carbon at the regional scale. *Geoderma*, **170**, 347-358.

14. Kerry, R., Goovaerts, P., Smit, I. and B.R. Ingram. 2012. A comparison of multiple indicator kriging and area-to-point Poisson kriging for mapping patterns of herbivore species abundance in Kruger National Park, South Africa. *International Journal of Geographical Information Science*, DOI:10.1080/13658816.2012.663917.

15. Zapata-Rios, X., Rivero, R.G., Naja, G.M., and P. Goovaerts. 2012. Spatial and temporal phosphorus distribution changes in a large wetland ecosystem, *Water Resources Research*, 48, W09512, doi: 10.1029/2011WR011421.

16. Speybroeck, N., Paraje, G., Prasad, A., Goovaerts, P., Ebener, S. and D.B. Evans. 2012. Inequality in human resources for health: measurement issues. *Geographical Analysis*, **44**, 151-161.

17. Tian, N., Goovaerts, P., Zhan, F.B., Chow, T.E. and J.G. Wilson. 2012. Identifying risk factors for disparities in breast cancer mortality among African-American and Hispanic women. *Women's Health Issues*, **22(3)**: e267-e276.

18. Goovaerts, P. 2011. A coherent geostatistical approach for combining choropleth map and field data in the spatial interpolation of soil properties. *European Journal of Soil Sciences*, **62**(3), 371-380.

19. Goovaerts, P., and H. Xiao. 2011. Geographical, temporal and racial disparities in late-stage prostate cancer incidence across Florida: A multiscale joinpoint regression analysis. *International Journal of Health Geographics*, **10**:63.

20. Xiao, H., Tan, F., and P. Goovaerts. 2011. Racial and geographic disparities in late-stage prostate cancer diagnosis in Florida. *Journal of Health Care for the Poor and Underserved*, **22**(4): 187-199.

21. Goovaerts, P. 2010. How do multiple testing correction and spatial autocorrelation affect areal boundary analysis? *Spatial and Spatio-temporal Epidemiology*, **1**(4), 219-229.

22. Goovaerts, P. 2010. Combining areal and point data in geostatistical interpolation: Applications to soil science and medical geography. *Mathematical Geosciences*, **42**(5), 535-554.

23. Goovaerts, P. 2010. Geostatistical analysis of county-level lung cancer mortality rates in the Southeastern US. *Geographical Analysis*, **42**, 32-52.

24. Goovaerts, P. 2010. Visualizing and testing the impact of place on late-stage breast cancer incidence: A non-parametric geostatistical approach. *Health and Place*, **16**, 321-330.

25. Burnicki, A., Brown, D.G., and P. Goovaerts. 2010. Propagating error in land-cover change analyses: impact of temporal dependence under increased thematic complexity. *International Journal of Geographic Information Science*, **24**(7), 1043-1060.

26. Jacquez, G., and P. Goovaerts. 2010. The emerging role and benefits of boundary analysis in spatio-temporal epidemiology and public health. *Spatial and Spatio-temporal Epidemiology*, **1**(4), 197-200.

27. Kerry, R., Goovaerts, P., Haining, R.P., and V. Ceccato. 2010. Applying geostatistical analysis to crime data: car-related thefts in the Baltic States. *Geographical Analysis*, **42**, 53-75.

28. Maxwell, S.K., Meliker, J.R., and P. Goovaerts. 2010. Use of land surface remotely sensed satellite and airborne data for environmental exposure assessment in cancer research**.** *Journal Of Exposure Science And Environmental Epidemiology*, **20**, 176-185.

29. Meliker, J.R., Goovaerts, P., Jacquez, G.M., and J.O. Nriagu. 2010. Incorporating individual-level distributions of exposure error in epidemiologic analyses: An example using arsenic in drinking water and bladder cancer. *Annals of Epidemiology*, **20**(10):750-758.

30. Meliker, J.R., Slotnick, M.J., AvRuskin, G.A., Schottenfeld, D., Jacquez, G.M., Wilson, M.L., Goovaerts, P., Franzblau, A., and J.O. Nriagu. 2010. Lifetime exposure to arsenic in drinking water and bladder cancer: A population-based case-control study in Michigan. *Cancer Causes & Control*, **21**:745-757.

31. Tian, N., Goovaerts, P., Zhan, F.B., and J.G. Wilson. 2010. Identification of racial disparities in breast cancer mortality: does scale matter? *International Journal of Health Geographics*, **9**:35.

32. Todd, M.J., Lowrance, R.R., Goovaerts, P., Vellidis, G., and C.M. Pringle. 2010. Geostatistical modeling of the spatial distribution of sediment oxygen demand within a Coastal Plain blackwater watershed. *Geoderma*, **59**(1-2), 53-62.

33. Ortiz, B.V., Perry, C., Goovaerts, P., Vellidis, G., and D. Sullivan. 2010. Geostatistical modeling of the spatial variability and risk areas of Southern Root-Knot nematodes in relation to soil properties. *Geoderma*, **156**(3-4), 243-252.

34. Goovaerts, P. 2009. Combining area-based and individual-level data in the geostatistical mapping of late-stage cancer incidence. *Spatial and Spatio-temporal Epidemiology*, **1**, 61-71.

35. Goovaerts, P. 2009. AUTO-IK: a 2D indicator kriging program for the automated non-parametric modeling of local uncertainty in earth sciences. *Computers and Geosciences*, **35**, 1255-1270.

36. Goovaerts, P. 2009. Medical geography: a promising field of application for geostatistics. *Mathematical Geosciences*, **41**(3), 243-264.

37. Delmelle, E.M. and P. Goovaerts. 2009. Second-phase sampling designs for non-stationary spatial variables? *Geoderma*, **153**(1-2), 205-216.

38. Gallagher, C.M., Goovaerts, P., Jacquez, G.M., Hao, Y., Jemal, A., and J.R. Meliker 2009. Racial disparities in lung cancer mortality in U.S. congressional districts, 1990–2001. *Spatial and Spatio-temporal Epidemiology*, **1**, 41-47.

39. Meliker, J.R., Goovaerts, P., Jacquez, G.M., AvRuskin, G.A., and G. Copeland. 2009. Breast and prostate cancer survival in Michigan: Can geographic analyses assist in understanding racial disparities? *Cancer*, 115(10), 2212-2221.

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39. Goovaerts, P. 1994. Comparison of CoIK, IK and mIK performances for modeling conditional probabilities of categorical variables. In R. Dimitrakopoulos, editor, *Geostatistics for the Next Century*, pages 18-29. Kluwer, Dordrecht.

40. Goovaerts, P. and Ph. Sonnet. 1993. Study of spatial and temporal variations of hydrogeochemical variables using factorial kriging analysis. In A. Soares, editor, *Geostatistics Troia '92*, volume 2, pages 745-756. Kluwer Academic Publishers, Dordrecht.

Other Publications

1. Goovaerts, P. 2007. Book review "Public Health Reasoning and Epidemic Modelling: The Case of Black Death", *Computers and Geosciences*, **33**(3): 445-446.

2. Goovaerts, P. 2006. A novel geostatistical approach for modeling, visualizing and propagating spatial uncertainty in cancer mortality maps. ISEE/ISEA 2006 Conference Abstracts Supplement, *Epidemiology*, **17**(6): Suppl:S113-S114.

3. Goovaerts, P., Auchincloss, A., and A.V. Diez-Roux. 2006. Performance comparison of spatial and space-time interpolation techniques for prediction of air pollutant concentrations in the Los Angeles area. *Proceedings of IAMG'2006*, Liege, September 4-8.

4. Goovaerts, P. 2005. Book review "Geostatistical Analysis of Compositional Data", *SIAM Review*, **47**(3): 605-606.

5. Goovaerts, P. 2005. Automatic interpolation of network data using indicator kriging. In G. Dubois, editor, EUR 21595. Automatic mapping algorithms for routine and emergency monitoring data. Office for Official Publications of the European Communities, Luxembourg, pages 89-101.

6. Goovaerts, P. 2005. Analysis and detection of health disparities using Geostatistics and a space-time information system. The case of prostate cancer mortality in the United States, 1970-1994. Proceedings of GIS Planet 2005, Estoril, May 30-June 2.

7. Goovaerts, P. 2005. Visualization and propagation of spatial uncertainty in cancer mortality rates using Poisson kriging and p-field simulation. Proceedings of Geocomputation 05, Ann Arbor, MI, July 2005.

8. Goovaerts, P. 2004. Book review "Spatial and temporal statistics: sampling field soils and their

vegetation", *Geoderma*, **123**: 189-190.

9. P. Goovaerts, G. AvRuskin, J. Meliker, M. Slotnick, G.M. Jacquez, J. Nriagu. 2004. Modeling uncertainty about pollutant concentration and human exposure using geostatistics and a space-time information system: Application to arsenic in groundwater of Southeast Michigan. In *Accuracy 2004: Proceedings of the 6th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences*.
10. Jacquez, G. M., G. AvRuskin, E. Do, H. Durbeck, D. A. Greiling, P. Goovaerts, A. Kaufmann, and B. Rommel. 2004. Complex Systems Analysis using Space-Time Information Systems and Model Transition Sensitivity Analysis. In *Accuracy 2004: Proceedings of the 6th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences*.
11. Goovaerts, P., Warner, A., Crabtree, B., Marcus, A. and G. Jacquez. 2003. Detection of local anomalies in high resolution hyperspectral imagery using geostatistical filtering and local spatial statistics. Proceedings of IEEE workshop on *Advances in Techniques for Analysis of Remotely Sensed Data*, NASA Goddard Visitor Center, Greenbelt MD, October 27-28, 2003.
12. Hirotaka, S., P. Goovaerts, S.A. McKenna. 2002. Impact of accuracy of prior information and geophysical sensors on geostatistical characterization of UXO sites. *The UXO/Countermine Forum*; Orlando, Fl, September 3-6, 2002.
13. S.A. McKenna , S. Hirotaka, P. Goovaerts. 2002. Estimating the spatial distribution of UXO from limited data using geostatistics. *The Countermine Forum*; Orlando, Fl, September 3-6, 2002.
14. Lemke, L.D., L.M. Abriola, and P. Goovaerts. 2002, Exploration of the influence of hydraulic property correlation on predictions of DNAPL infiltration and entrapment, Groundwater 2002 IAHR Groundwater Symposium Proceedings; Berkeley, CA, Mar 25-29, 2002.
15. Sasena, M.J., Papalambros, P.Y. and P. Goovaerts. 2002. Global Optimization of Problems with Disconnected Feasible Regions via Surrogate Modeling. To appear in the 9th AIAA/NASA/USAF/ISSMO Symposium on Multidisciplinary Analysis and Optimization, September 4-6, 2002. Paper No. AIAA-2002-5573.
16. Barabás, N., P. Adriaens, P. Goovaerts. 2001. Geostatistical assessment of natural transformation of dioxins in estuarine sediments. In SETAC 22nd Annual Meeting. Changing Environmental Awareness: Societal Concerns and Scientific Responses. Society of Environmental Toxicology and Chemistry, Baltimore, Maryland.
17. Sasena, M.J., Papalambros, P.Y. and P. Goovaerts, 2001. The Use of Surrogate Modeling Algorithms to Exploit Disparities in Function Computation Time within Simulation-Based Optimization. Presented at the Fourth Congress of Structural and Multidisciplinary Optimization in Dalian, China, June 4-8, 2001.
18. Lemke, L.D., E.J. Hahn, C.D. Drummond, K.M. Rathfelder, L.M. Abriola, and P. Goovaerts, 2000. Comparison of sequential Gaussian and sequential indicator geostatistical simulations using three-dimensional flow and transport models in a homogenous, non-uniform aquifer [abstr]: Gordon Research Conference (Modeling Flow and Transport in Porous Media) Aug, 6-10, 2000.
19. Sasena, M.J., Papalambros, P.Y., and P. Goovaerts. 2000. Metamodeling sampling criteria in a global optimization framework, Proceedings of the 8th AIAA/NASA/USAF/ISSMO Symposium on

Multidisciplinary Analysis and Optimization, Long Beach, CA, Sept. 2000, AIAA-2000-4921.

20. Barabás, N., Goovaerts, P. and P. Adriaens. 2000. Geostatistical Interpretation of Dioxin Reactivity in Sediments. DIOXIN 2000 20th International Symposium on Halogenated Environmental Organic Pollutants & POPS. Proceedings. Vol. 45, pages 332-335.
21. Adriaens, P., A.L. Barkovskii, Q. S. Fu, N. Barabás and P. Goovaerts, 2000. Extrapolation of Laboratory-Derived Dioxin Dechlorination Patterns to the Field: Assessing Natural Attenuation in Passaic River Sediments. 16th Ann. Int. Conf. Contam. Soils, Sediments and Water, Amherst, MA.
22. Goovaerts, P. 2000. Geostatistical Mapping of Satellite Data using P-field simulation with conditional probability fields. Proceedings of the Fourth International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences (Amsterdam), pp. 253-260.
23. Goovaerts, P. 1999. Combining minimum error variance and spatial variability in the modeling of petrophysical properties. Stanford Center for Reservoir Forecasting, Stanford University, Unpublished annual report No 12.
24. Goovaerts, P. 1999. Combining minimum error variance and spatial variability in the mapping of environmental variables. In H.T. Mowrer, R.L. Czaplewski and R.H. Hamre, editors, *Spatial Accuracy Assessment in Natural Resources and Environmental Sciences: Third International Symposium*, Ann Arbor Press, Michigan, pages 299-306.
25. Goovaerts, P. 1998. Regional estimation of soil properties from local observations. In Proceedings of the Soil Quality Workshop, Alberta Agriculture Food, and rural development, Edmonton January 30-31, 1998, pages 51-58.
26. Goovaerts, P. 1998. Impact of the simulation algorithm, magnitude of ergodic fluctuations and number of realizations on the spaces of uncertainty of flow predictions. Stanford Center for Reservoir Forecasting, Stanford University, Unpublished annual report No 11.
27. Goovaerts, P. 1997. Algorithmically-defined spaces of uncertainty for flow properties. In V. Pawlowsky-Glahn, editor, *Proceedings of IAMG'97*, pages 848-853. CIMNE, Barcelona.
28. Goovaerts, P. 1997. Book review "Le sol: Interface dans l'Environnement, Ressource pour le Developpement", *Geoderma*, **75**: 149-150.
29. Goovaerts, P. and A.G. Journel. 1995. Integration of soil map (facies) information in modelling the spatial variation of continuous soil (petrophysical) properties. Stanford Center for Reservoir Forecasting, Stanford University, Unpublished annual report No 8.
30. Hennebert, P. and P. Goovaerts. 1995. Spatial variability of chemical properties and experimental design on an oxisol in Burundi. In *AFRICALAND, Management of Acid Soils, Land Development for Sustainable Agriculture*, 5th Regional Workshop, Network review, Bujumbura, Burundi, 6-11 May 1992, pages 49-68.
31. Goovaerts, P. 1994. On the necessity of checking the Markov approximation and the collocated cokriging alternative. *Geostatistics*, **7**(1): 10-12.
32. Goovaerts, P. 1994. Prediction and stochastic modelling of facies types using classification algorithms and simulated annealing. Stanford Center for Reservoir Forecasting, Stanford University, Unpublished annual report No 7.

33. Goovaerts, P. 1993. Comparative performance of indicator cokriging vs kriging in estimating conditional probabilities of categorical variables, using a large categorical soil data set. Stanford Center for Reservoir Forecasting, Stanford University, Unpublished annual report No 6.

Invited Lectures, presentations or seminars (1996-present)

1. *A Geostatistical Approach for Integrating the Spatial Uncertainty in Environmental Decision-Making*, Departement de Genie Rural, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland, April 96.
2. *Geostatistics and GIS for Environmental Applications*, Department of Soil Management, Gent University, May 96.
3. *Accounting for local uncertainty in environmental decision-making processes*, 5th International Geostat Congress, Wollongong (Australia), September 96.
4. *Application of Geostatistics to Environmental Sciences*, Department of Statistics, Catholic University of Louvain-la-Neuve, Belgium, October 96.
5. *Kriging vs stochastic simulation for risk analysis in soil contamination*, 1st European meeting on Geostatistics for Environmental Applications, Lisbon, November 96.
6. *Geostatistical Modeling of Uncertainty and its Incorporation in Environmental Decision-Making Processes*, Department of Civil and Environmental Engineering, The University of Michigan, April 97.
7. *Geostatistics in Soil Science: State-of-the-Art and Perspectives*, opening keynote address at Pedometrics'97, Madison (WI), August 97.
8. *Algorithmically-defined spaces of uncertainty for flow properties*, 3rd Annual Conference of the International Association for Mathematical Geology, Barcelona, September 1997.
9. *Delineation of Hot-Spots of Contamination Using Geostatistics and Point Measurements of Soil Quality*, invited speaker at Milieuplatform 97, University of Leuven (Belgium), October 97.
10. *Geostatistical Assessment of the Risk of Soil Contamination by Heavy Metals and its Incorporation in the Delineation of Hazardous Areas*, AGU Chapman Conference on Applications of GIS, Remote Sensing, Geostatistics, and Solute Transport Modeling to the Assessment of Nonpoint Source Pollutants in the Vadose Zone, Riverside (CA), October 97.
11. *Stochastic Simulation of Lithofacies and Reservoir Properties using Simulated Annealing*, French Institute of Petroleum, Paris, January 98.
12. *Regional Estimation of Soil properties from Local Observations*, invited speaker at Soil Quality Workshop organized by Alberta Agriculture Food, and rural development, Edmonton, January 98.
13. *Quantifying Environmental Risks Through Stochastic Simulation*, Department of Mathematics, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland, February 98.
14. *Impact of the Simulation Algorithm, Magnitude of Ergodic Fluctuations and Number of Realizations on the Spaces of Uncertainty of Flow Predictions*, Stanford Center for Reservoir Forecasting, 11th annual meeting, May 98.
15. *Combining Minimum Error Variance and Spatial Variability in the Mapping of Environmental Variables*, 3rd International Symposium on Accuracy Assessment in Natural Resources and Environmental Sciences, Quebec, May 98.
16. *Impact of the Simulation Algorithm, Magnitude of Ergodic Fluctuations and Number of Realizations*

on the Spaces of Uncertainty of Flow Predictions, NACOG meeting, Santa Fe, New Mexico, July 98.

17. *Combining Minimum Error Variance and Spatial Variability in the Mapping of Soil properties*, Workshop of the AISS Pedometrics Group on Advanced in Soil Geostatistics, Montpellier, August 98.
18. *Quantifying Environmental Risks Through Stochastic Simulation*, Department of Statistics, University of Michigan, September 98.
19. *Geostatistics in Soil Science: State-of-the-Art and Perspectives*, CANR Biometry Group Seminar Series, Michigan State University, East Lansing, September 98.
20. *Geostatistical Modeling of Spatial Variability*, IESET Seminar Series, University of Michigan, November 98.
21. *Accounting for Scale-dependent Correlation in the Spatial Prediction of Soil Properties*, 2nd European meeting on Geostatistics for Environmental Applications, Valencia, November 98.
22. *Performance Comparison of Geostatistical Algorithms for Incorporating Elevation into the Mapping of Precipitation*, Technical University of Lisbon, Lisbon, March 99.
23. *Geostatistics in Soil Ecology: State-of-the-Art and Perspectives*, Kellogs Ecological Station, Kalamazoo, March 99.
24. *Combining Minimum Error Variance and Spatial Variability in the Modeling of Petrophysical Properties*, invited speaker at 5th SIAM conference, mini-symposium on "Recent developments in stochastic modeling and simulation", San Antonio, March 99.
25. *Applications of Geostatistics*, Colloquium Series in Applications of Spatial Statistics, University of Wisconsin, Madison, April 99.
26. *Combining Minimum Error Variance and Spatial Variability in the Modeling of Petrophysical Properties*, Stanford Center for Reservoir Forecasting, 12th annual meeting, May 99.
27. *Geostatistics in Environmental Sciences: State-of-the-Art and Perspectives*, International Symposium of Geoinformatics and Socioinformatics, University of Michigan, Ann Arbor, June 99.
28. *Environmental Geostatistics: State-of-the-Art and Perspectives*, invited speaker at NCR 170 meeting, University of Illinois, Urbana. July 99.
29. *Performance Comparison of Geostatistical Algorithms for Incorporating Elevation into the Mapping of Precipitation*, Geocomputation 99, Fredericksburg, Virginia, July 99.
30. *Combining Minimum Error Variance and Spatial Variability in the Modeling of Petrophysical Properties*, keynote address at the 5th Annual Conference of the International Association for Mathematical Geology, Trondheim, Norway, August 99.
31. *Kriging versus Stochastic Simulation for Quantifying Uncertainty in Environmental Applications*, invited speaker at Joint Statistical Meetings 1999, Baltimore, Maryland, August 99.
32. *Geostatistical Modeling of Uncertainty in Soil Science*, keynote address at Pedometrics'99, Sydney, Australia, September 99.
33. *Performance Comparison of Geostatistical Algorithms for Incorporating Elevation into the Mapping of Precipitation*, guest speaker at Geostatistical Association of Australia, Perth, Australia, October 99.

34. *Geostatistical Assessment of the Risk of Exceeding Location-specific Thresholds and its Impact on Sampling Designs: Application to Airborne Cd Contamination*, NACOG meeting, Austin, Texas, October 99.
35. *Geostatistical Mapping of Satellite Data using P-field Simulation with Conditional Probability Fields*, Fourth International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Amsterdam, The Netherlands, July 2000.
36. *Geostatistical Mapping of Satellite Data using P-field Simulation with Conditional Probability Fields*, NACOG meeting, Ann Arbor, August 2000.
37. *Is there a future for Geostatistics in Remote Sensing and Exposure Assessment*? Workshop on "Exposure Assessment Using High Spatial Resolution, Hyperspectral Imagery: Challenges and Opportunities", Ann Arbor, August 2000.
38. *Accounting for Measurement Error in Uncertainty Modeling and Decision Making using Indicator Kriging and p-field Simulation: Application to a Dioxin Contaminated Site*, Fourth International Conference on Environmetrics and Chemometrics, Las Vegas, September 2000.
39. *Geostatistical Assessment of Scale-dependent Correlation Between Soil Properties*, Kirkham conference 2000, Iowa State University, November 2000.
40. *Delineation of Hazardous Areas and Additional Sampling Strategy in Presence of a Location-specific Threshold*, 3rd European meeting on Geostatistics for Environmental Applications, Avignon, November 2000.
41. *Geostatistical Incorporation of Spatial Coordinates into Supervised Classification of Hyperspectral Data*, invited speaker at Joint Statistical Meetings 2001, Atlanta, Georgia, August 2001.
42. *Geostatistical Modeling of Spatial Uncertainty using p-field Simulation*, Biomedware, Ann Arbor, August 2001.
43. *Accounting for Measurement and Interpolation Errors in Soil Contaminant Mapping and Decision-Making*, 7th Annual Conference of the International Association for Mathematical Geology, Cancun, Mexico, September 2001.
44. *Assessment of the Production and Economic Risks of Site-specific Liming using Geostatistical Uncertainty Modelling*, Pedometrics'01, Gent, Belgium, September 2001.
45. *Geostatistical Modeling and Propagation of Uncertainty in Soil Science*, invited speaker at 2001 ASA-CSSA-SSSA Annual Meetings, Charlotte, North Carolina, October 2001.
46. *Bayesian Approach to UXO Site Characterization with Incorporation of Geophysical Information*, SERDP In-Progress Review meeting, Washington DC, May 2002.
47. *Geostatistical Integration of Monitoring Data and GIS Layers*, invited speaker at International Symposium on Environmental Biotechnology 2002, Veracruz, Mexico, June 2002.
48. *Geostatistical Modeling and Propagation of Uncertainty: Application to the Management of Agricultural Fields*, 8th Annual Conference of the International Association for Mathematical Geology, Berlin, Germany, September 2002.
49. *Exploration of Scale-dependent Correlation Between Cancer Mortality Rates in Both Space and Time using Geostatistics*, Conference on "Space Time Information Systems", Ann Arbor, January 2003.

50. *A Naive Geostatistical Analysis of Microscopy Imagery*, Conference on "Analysis of Colocalization in Microscopy Imagery", Ann Arbor, March 2003.
51. *Exploring Scale-dependent Correlation Between Cancer Mortality Rates using Geostatistics*, National Cancer Institute, Washington DC, April 2003.
52. *Introduction to Geostatistical Methods*, Mini Symposium on "Spatial Methods for Environmental Sampling, Risk Characterization, and Management", World Congress on Risk, Brussels, Belgium, June 2003.
53. *Building Spatially Distributed Models using Geostatistics: A Review and Potential Applications to the Prediction of Spread of Infectious Diseases*, Conference on "Model Transition Sensitivity Analysis", Ann Arbor, July 2003.
54. *Assessment of the Production and Economic Risks of Site-specific Liming using Geostatistical Uncertainty Modelling*, Geocomputation 2003, Southampton, UK, September 2003.
55. *Selective Remediation of Contaminated Sites using a Two-level Multiphase Strategy and Geostatistics*, Pedometrics'03, Reading, UK, September 2003.
56. *Partnerships for Technological Transfer of Enabling Technology to Public Health: Geostatistical Filtering as an Answer to the Small Numbers Problem*, GeoMed 03, Baltimore, Maryland, October 2003.
57. *Detection of Local Anomalies in High Resolution Hyperspectral Imagery using Geostatistical Filtering and Local Spatial Statistics*, IEEE workshop on Advances in Techniques for Analysis of Remotely Sensed Data, NASA Goddard Visitor Center, Greenbelt, Maryland, October 2003.
58. *Neutral Models for Pattern Recognition on Remotely Sensed Imagery*, Biomedical Information Science and Technology Initiative (BISTI), 2003 Symposium, Digital Biology: The Emerging Paradigm, Bethesda, Maryland, November 2003.
59. *Geostatistical Modeling of Uncertainty Attached to the Spatial Distribution of Arsenic in Groundwater of Southeast Michigan*, AGU Fall Meeting, San Francisco, California, December 2003.
60. *Modeling Uncertainty about Pollutant Concentration and Human Exposure using Geostatistics and a Space-time Information System: Application to Arsenic in Groundwater of Southeast Michigan*, Tufts University, Boston, MA, April 2004.
61. *The Geostatistical Pandora Box*, invited speaker, Spatial Analysis and Decision Assistance 2004 NRC Workshop, Rockville, Maryland, May 2004.
62. *Software for the Analysis of Health and Exposure Data*, Conference on "Software for the Analysis of Health and Exposure Data", Ann Arbor, May 2004.
63. *Long Island Study Revisited*, Conference on "Software for the Analysis of Health and Exposure Data", Ann Arbor, May 2004.
64. *Modeling Uncertainty about Pollutant Concentration and Human Exposure using Geostatistics and a Space-time Information System: Application to Arsenic in Groundwater of Southeast Michigan*, Spatial Accuracy Invited Lecturer, Sixth International Symposium on Spatial Accuracy Assessment in Natural resources and Environmental Sciences, Portland, Maine, June 2004.
65. *Simulation-based Assessment of a Geostatistical Approach for Estimation and Mapping of the Risk of*

Cancer, Seventh International Geostatistics Congress, Banff, Alberta, Canada, September 2004.

66. *Detection of Local Anomalies in High Resolution Hyperspectral Imagery using Geostatistical Filtering and Local Spatial Statistics*, Seventh International Geostatistics Congress, Banff, Alberta, Canada, September 2004.
67. *Detection of Spatial Clusters and Outliers using the LISA Statistics and Geostatistically Simulated Spatial Neutral Models*, Fifth European Conference on Geostatistics for Environmental Applications (GeoENV 2004), Neuchatel, Swizerland, October 2004.
68. *Detection of Local Anomalies in High Resolution Hyperspectral Imagery using Geostatistical Filtering and Local Spatial Statistics,* AGU Fall Meeting, San Francisco, California, December 2004.
69. *Modeling Uncertainty about Pollutant Concentration and Human Exposure using Geostatistics and a Space-time Information System: Application to Arsenic in Groundwater of Southeast Michigan*, University of Florida, Gainesville, Fl, March 2005.
70. *Analysis and Detection of Health Disparities using Geostatistics and a Space-time Information System,* GIS Planet 2005, Estoril, Portugal, May 2005.
71. *Visualization and Propagation of Spatial Uncertainty in Cancer Mortality Rates using Poisson Kriging and p-field Simulation*, GeoComputation 05, Ann Arbor, MI, July 2005.
72. *Exploring the Spatial Non-stationarity of Relationships among Soil Properties Using Geographically-weighted Regression*, Pedometrics 05, Naples, FL, September 2005.
73. *Exploring the Non-stationarity of Relationships among Spatial Attributes using Geographically-weighted Regression and Geostatistical Neutral Models*, University of California, Santa Cruz, CA, January 2006.
74. *Modeling the Impact of the Environment on Human Health: How can Geostatistics and Space-Time Information Systems help you?*, Stanford University, Palo Alto, CA, January 2006.
75. *Visualization and Analysis of Health data using a Space-time Information System*, World Health Organization, Geneva, Switzerland, February 2006.
76. *Performance Comparison of Spatial and Space-time Interpolation Techniques for Prediction of Air Pollutant Concentrations in the Los Angeles Area,* Association of American Geographers Annual Meeting, Chicago, IL, March 2006.
77. *Analysis and Detection of Health Disparities using Geostatistics and a Space-time Information System: The case of prostate cancer mortality in the United States, 1970-1994*, Center for Minority Prostate Cancer Training & Research, Tallahassee, FL, March 2006.
78. *A Novel Geostatistical Approach for Modeling, Visualizing and Propagating Spatial Uncertainty in Cancer Mortality Maps*, International Conference on Environmental Epidemiology & Exposure, Paris, France, September 2006.
79. *Performance Comparison of Spatial and Space-time Interpolation Techniques for Prediction of Air Pollutant Concentrations in the Los Angeles Area*, 12th Annual Conference of the International Association for Mathematical Geology, Liege, Belgium, September 2006.

80. *Geostatistical Analysis of Health Data: State-of-the-art and Perspectives*, opening keynote address at Sixth European Conference on Geostatistics for Environmental Applications (GeoENV 2006), Rhodes, Greece, October 2006.
81. *Exploring Health Disparities using Geostatistics and a Space-time Information System: The case of prostate and cervix cancer mortality in the United States, 1970-1994*, invited speaker, Race, Ethnicity and Place Conference III, San Marcos, Texas, November 2006.
82. *Space-Time Visualization and Geostatistical Analysis of Environmental and Health Data*, Fall ilGISa (Illinois Geographic Information Systems Association) 2006 meeting, Chicago, Illinois, November 2006.
83. *Space-Time Visualization and Detection of Health Disparities using Geostatistics and a Space-time Information System: The case of prostate and cervix cancer mortality in the United States, 1970-1994*, Association of American Geographer's 2007 annual meeting, San Francisco, California, March 2007.
84. *Space-Time Visualization and Detection of Health Disparities using Geostatistics and a Space-time Information System: The case of prostate and cervix cancer mortality in the United States, 1970-1994*, URISA's GIS in Public Health Conference, New Orleans, Louisiana, May 2007.
85. *Geostatistical Modeling of the Spatial Distribution of Soil Dioxin in the Vicinity of an Incinerator*, invited speaker, 56th session of the International Statistical Institute, Lisbon, Portugal, August 2007.
86. *Geostatistical Modeling of the Spatial Distribution of Soil Dioxin in the Vicinity of an Incinerator*, Pedometrics 07, Tuebingen, Germany, August 2007.
87. *Geostatistical Modeling of the Spatial Distribution of Soil Dioxin in the Vicinity of an Incinerator*, 17th Annual Conference of the International Society of Exposure Analysis, Durham, North Carolina, October 2007.
88. *Space-Time Visualization and Detection of Health Disparities using Geostatistics and a Space-time Information System: The case of prostate and cervix cancer mortality in the United States, 1970-1994*, 2007 AACR conference on The Science of Cancer Health Disparities in Racial/Ethnic Minorities and the Medically Underserved, Atlanta, Georgia, November 2007.
89. *Geostatistical Analysis of Health Data: State-of-the-art and Perspectives*, Association of American Geographer's 2008 annual meeting, Boston, Massachusetts, March 2008.
90. *Visualization and Analysis of Health data using a Space-time Information System*, Center for Minority Prostate Cancer Training & Research, Tallahassee, FL, March 2008.
91. *Recent Development in Applied Geostatistics: Going Beyond the Generation of Pretty Color Maps*, Rutgers, The State University of New Jersey, New Brunswick, NJ, June 2008.
92. *Problems and Some Solutions in the Analysis of Spatial Data*, National Geospatial Agency, Washington DC, June 2008.
93. *Space-Time Visualization and Detection of Health Disparities using Geostatistics and a Space-time Information System: The case of prostate and cervix cancer mortality in the United States, 1970-1994*, 2008 NIH SBIR/STTR Conference, Atlanta, Georgia, July 2008.

94. *How can Geostatistics Help Quantifying Uncertainty in Water Management Applications?*, St. Johns River Water Management District, Palatka, Florida, August 2008.
95. *Applications of Geostatistics in Cancer Studies*, Seventh European Conference on Geostatistics for Environmental Applications (GeoENV 2008), Southampton, United Kingdom, September 2008.
96. *Recent Applications of Geostatistics to Environmental Epidemiology*, invited speaker, Workshop on Spatial Epidemiology, Instituto Superior Técnico of Lisbon, Portugal, September 2008.
97. *Geostatistical Analysis of Health and Exposure Data: State-of-the-art and Perspectives*, International Conference on Environmental Epidemiology & Exposure, Pasadena, California, October 2008.
98. *New Geospatial Approaches to Cancer Control and Surveillance*, Department of Geography, UC Santa Barbara, California, October 2008.
99. *How Can Geostatistics be Tailored to the Analysis of Environmental Health Data?*, Eighth International Geostatistics Congress, Santiago, Chile, December 2008.
100. *Geostatistical Estimation of Contaminated Sediment Volumes: Review of Common Challenges and Solutions*, Fifth International Conference on Remediation of Contaminated Sediments, Jacksonville, Florida, February 2009.
101. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, Association of American Geographer's 2009 annual meeting, Las Vegas, Nevada, March 2009.
102. *Geostatistical Mapping of Late Stage Breast Cancer Incidence*, URISA's GIS in Public Health Conference, Providence, Rhode Island, June 2009.
103. *Geostatistical Estimation of Contaminated Sediment Volumes: Review of Common Challenges and Solutions*, StatGIS 2009, Milos, Greece, June 2009.
104. *Automatic Classification of Landsat Timeseries using Geostatistics and Discriminant Analysis*, StatGIS 2009, Milos, Greece, June 2009.
105. *Geostatistical Estimation of Contaminated Sediment Volumes: Review of Common Challenges and Solutions*, 15th Annual Conference of the International Association for Mathematical Geosciences, Stanford University, California, August 2009.
106. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, keynote address at 15th Annual Conference of the International Association for Mathematical Geosciences, Stanford University, California, August 2009.
107. *Geostatistical Space-time models of Environmental Contaminants*, SETAC (Society of Environmental Toxicology and Chemistry) North America 30th Annual Meeting, New Orleans, Louisiana, November 2009.
108. *Geostatistical Estimation of Contaminated Sediment Volumes: Review of Common Challenges and Solutions*, Association of American Geographer's 2010 annual meeting, Washington, DC, March 2010.
109. *Three-dimensional Visualization, Interactive Analysis and Contextual Mapping of Space-time Cancer Data*, 13th Agile International conference, Guimarães, Portugal, May 2010.

110. *Three-dimensional Visualization, Interactive Analysis and Contextual Mapping of Space-time Data*, 16th Annual Conference of the International Association for Mathematical Geosciences, Budapest, Hungary, August 2010.
111. *Visualizing the Impact of Place and Race on Late-stage Cancer Incidence*, invited speaker, Race, Ethnicity and Place Conference V, Binghamton, New-York, October 2010.
112. *Visualizing the Impact of Time, Place and Race on Late-stage Cancer Incidence*, School of Public Health, University of Illinois, Chicago, November 2010.
113. *Geostatistical Boundary Analysis of Temporal Trends in Late-stage Prostate Cancer Incidence across Florida*, Spatial Statistics 2011, Enschede, The Netherlands, March 2011.
114. *Visualizing the Impact of Time, Place and Race on Late-stage Cancer Incidence*, Association of American Geographer's 2011 annual meeting, Seattle, WA, April 2011.
115. *Merging Areal and Point Data in Medical Geography and Soil Mapping*. Geocomputation 2011, London, United Kingdom, July 2011.
116. *Space-time Trend Analysis of Health Outcomes: Prostate Cancer Late-stage Diagnosis in Florida*. The International Symposium on Spatial-Temporal Analysis and Data Mining, London, United Kingdom, July 2011.
117. *The Role of Geostatistics in Medical Geology*, keynote address at VIII Iberian Geochemistry Conference / XVIII Geochemical Week, Castelo Branco, Portugal, September 2011.
118. *The Role of Geostatistics in Medical Geology*, GEOMED 2011, 4th International conference on Medical geology, Bari, Italy, September 2011.
119. *Geostatistics Applied to Environmental Epidemiology*, Xi'an University, Xi'an, China, November 2011.
120. *Geostatistical Analysis of Health Data with Different Levels of Aggregation*, First International Conference on Geospatial Geocoding, Redland, California, December 2011.
121. *Geostatistical Change of Support*, ESRI campus, Redland, California, December 2011.
122. *Recent Developments in Geostatistics: Change of Support and Spatial Analysis of Temporal Trends in Health Outcomes*, Seminar at ISEGI, Universidade Nova de Lisboa, Portugal, February 2012.
123. *Geostatistics in Practice*, Seminar at Wayne State University, Detroit, Michigan, April 2012.
124. *Visualization and Comparison of Spaces of Uncertainty using Three-dimensional Display and Multi-dimensional Scaling*, 14th Agile International conference, Avignon, France, April 2012
125. *Visualization and Comparison of Spaces of Uncertainty using Three-dimensional Display and Multi-dimensional Scaling*, 2012 meeting of Stanford Center for Reservoir Forecasting, Asilomar, California, May 2012.
126. *The Role of Geostatistics in Environmental Epidemiology*, keynote address at 9th International Symposium on Environmental Geochemistry, Aveiro, Portugal, July 2012.
127. *Challenges Associated With the Application of Geostatistics to Survey Data*, Meeting of the Spatial Sciences Node of the NSF-Census Research Network (SS-NCRN) "Measuring People in Place", Boulder, Colorado, October 2012.

128. *Geographical, Temporal and Racial Disparities in Late-stage Prostate Cancer Incidence across Florida: A Multiscale Joinpoint Regression Analysis*, invited speaker, Race, Ethnicity and Place Conference VI, San Juan, Puerto Rico, October 2012.
129. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Brazilian National Institute for Space Research - INPE, Brazil, March 2013.
130. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, Brazilian National Institute for Space Research – INPE, Brazil, March 2013.
131. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Institut Agronomique et Vétérinaire Hassan II Rabat, Morocco, March 2013.
132. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Office Chérifien des Phosphates(OCP), Benguérir, Morocco, March 2013.
133. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Middle East Technical University, Turkey, April 2013.
134. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, Middle East Technical University, Turkey, April 2013.
135. *The Role of Geostatistics in Medical Geology*, invited speaker, IAMG Distinguished Lecture, Conservatoire national des arts et Métiers, France, April 2013.
136. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, ITC, Netherlands, April 2013.
137. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, Department of Earth Sciences, Utrecht University, Netherlands, April 2013.
138. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Royal Institute of Technology, Stockholm, Sweden, April 2013.
139. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, National Chung Hsing University, Taichung, Taiwan, May 2013.
140. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, National Taiwan University, Tapei, Taiwan, May 2013.
141. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, National Cheng Kung University, Tainan, Taiwan, May 2013.
142. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, International School for Geoscience Resources (KIGAM), South Korea, May 2013.
143. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Tokyo University of Agriculture & Technology, Japan, May 2013.

144. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Kyoto University, Japan, May 2013.

145. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Hokkaido University, Japan, May 2013.

146. *Visualization and Comparison of Spaces of Uncertainty using Three-dimensional Display and Multi-dimensional Scaling*, Spatial Statistics 2013, Columbus, Ohio, June 2013.

147. *Space-time Analysis of Late-stage Breast Cancer Incidence in Michigan*, 2013 International Medical Geography Symposium, Lansing, Michigan, July 2013.

148. *Geostatistical Mapping of Dioxin and Arsenic in Soils around Point Sources of Contamination*, invited speaker, IAMG Distinguished Lecture, University of Cape Town, South Africa, August 2013.

149. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Stellenbosch University, South Africa, August 2013.

150. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Kruger National Park, South Africa, August 2013.

151. *Geostatistical Mapping of Dioxin and Arsenic in Soils around Point Sources of Contamination*, Pedometrics 2013, Nairobi, Kenya, August 2013.

152. *Geostatistics: a Common Link Between Medical Geography, Mathematical Geology and Medical Geology*, 19th Annual Conference of the International Association for Mathematical Geosciences, Madrid, Spain, September 2013.

153. *A Spatial Statistical Approach for Sedimentary Gold Exploration – a Portuguese Case Study*, 19th Annual Conference of the International Association for Mathematical Geosciences, Madrid, Spain, September 2013.

154. *The Role of Geostatistics in Medical Geology*, invited speaker, IAMG Distinguished Lecture, Spanish Geological Survey, Madrid, Spain, September 2013.

155. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, Instituto Superior Técnico of Lisbon, Portugal, September 2013.

156. *Geostatistics Analysis of Imagery Data: a Brief Overview and Recent Developments*, invited speaker, IMA (Institute for Mathematics and its Applications) Workshop Imaging in Geospatial Applications, Minneapolis, Minnesota, October 2013.

157. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Edith Cowan University, Perth, Australia, October 2013.

158. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, BHP Billiton, Perth, Australia, October 2013.

159. *Geostatistical Characterisation of Soil and Sediment Contamination: Leaving the Ivory Tower for the Field*, keynote address at Walis Forum, Perth, New Australia, November 2013.

160. *The Impact of Place and Time on the Proportion of Late-stage Diagnosis: The Case of Prostate Cancer in Florida and Breast Cancer in Michigan*, keynote address at CRCSI (Cooperative Research Center for Spatial Information) Annual Conference, Christchurch, New Zealand, November 2013.

161. *Geostatistics in Practice*, invited speaker, IAMG Distinguished Lecture, Landcare Research, Palmerston North, New Zealand, November 2013.

162. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, Landcare Research, Lincoln, New Zealand, November 2013.

163. *Combining Areal & Point Data in Geostatistical Interpolation: Applications to Soil Science & Medical Geography*, invited speaker, IAMG Distinguished Lecture, Université de Liège, Liège, Belgium, December 2013.

164. *Applying Geostatistics to Crime Data: Development of Predictive & Prevention Models*, invited speaker, Portuguese National Republican Guard (GNR) headquarters, Lisbon, Portugal, January 2014.

165. *Environmental Protection using Geostatistical Time Models*, invited speaker, Portuguese National Republican Guard (GNR) headquarters, Lisbon, Portugal, January 2014.

166. *Geostatistics in Practice*, invited speaker, Hope University, Liverpool, UK, March 2014.

167. *Geostatistics in Practice*, invited speaker, UCLA Department of Statistics, Los Angeles, April 2014.

168. *Geostatistics in Practice*, invited speaker, Wayne State University Department of Geology, Detroit, April 2014.

169. *The Role of Geostatistics in Medical Geology*, solicited speaker, European Geophysical Union Meeting 2014 (EGU 2014), Vienna, Austria, April 2014.

170. *The Impact of Place and Time on the Proportion of Late-stage Diagnosis: The Case of Breast Cancer in Michigan and Prostate Cancer in Florida*, invited speaker, Washington University School of Medicine, Siteman Cancer Center, St Louis, May 2014.

171. *The Importance of Spatial Support in Environmental Modeling and Decision-making*, keynote address at 11th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Lansing, Michigan, July 2014.

172. *Application of Geostatistics to Environmental Epidemiology: The Case of Lung Cancer Mortality in the Southeastern US*, invited presentation at International Conference on Multidisciplinary Cancer Care, Bogota, Colombia, September 2014.

173. *The Importance of Spatial Support in Environmental Modeling and Decision-making: A Geostatistical Approach*, invited seminar, Aix Marseille University, Marseille, France, October 2014.

174. *Application of Boundary Analysis to Medical Geology*, 20th Annual Conference of the International Association for Mathematical Geosciences, New Delhi, India, October 2014.

175. *The Role of Geostatistics in Environmental Epidemiology*, invited seminar, Institute of Environmental Health Sciences, Wayne State University, Detroit, Michigan, December 2014.

EXHIBIT 2

Day care facilities & schools with WLL ≥ 1 μg/L

Alleree Billings
Angie McNeal
Betty Joe Pea day
Brownell STEM Academy
Cathedral of Faith Head Start
Cummings/Great Expectations Daycare
Doyle/Ryder Elementary
Durant Tuuri Mott Elementary
Eagles Nest Academy
Eisenhower Elementary
Flint Community Schools, Central Kitchen
Flint Institute of Music
Flint Youth Theater
Flint/Genesee Job Corps Center
Freeman Elementary
Gail Sewell
GCCARD Child Dvpt Center
Genesee STEM Academy
Gloria Little Angels Child Care Center
Heavenly Angels
Holmes STEM Academy
Honey Bee Palace Child care center
Jane Zitterkoph
Janice Mobley Daycare
Just for Kids Daycare
Kiddie Time Childcare Center
Kiwanis House
Leali Alexander's daycare
Lisa Ann Adams daycare
Lori Hill daycare
Luke M. Powers Catholic High School
Manley school
Michigan School for the Deaf
Mott Early Childhood Learning
Neithercut Elementary School
New Standard Academy
Northridge Academy
Northwestern High School Report
Optimist house
Pierce Elementary
Potter Elementary
Reach
Richfield Elementary School
Rotary house
Sand Castle child dvpt
Southwestern Classical Academy

St. John Vianney School
St. Paul Lutheran School
St. Pius X School
Summerfield Academy
Sunny Patch Learning Center
Teddy Bears/Patrice Moore daycare
Transition living Program
WAY Academy of Flint
Whaley Children's Center
Zonta House

EXHIBIT 3

LIST OF REFERENCES

Exhibit	Description
1	Goovaerts, P. 2011. Fate and Transport: Geostatistics and Environmental Contaminants. In: Nriagu JO (ed.) *Encyclopedia of Environmental Health*, volume 2, pp. 701–714 Burlington: Elsevier
2	Goovaerts, P. 2007. Spatial uncertainty in medical geography: A geostatistical perspective. In S. Shekhar and H. Xiong (eds) *Encyclopedia of GIS*. Springer-Verlag, Berlin, Germany, 1106-1112
3	Jacquez, G.M., Meliker, J.R., Rommel, R.R., and P.E. Goovaerts. 2019. Exposure reconstruction using space–time information technology. In: Nriagu JO (ed.) *Encyclopedia of Environmental Health*, volume 2, pp. 793–804 Burlington: Elsevier
4	Goovaerts, P. 2005. Geostatistical Analysis of Spatial Data, in 6.64 Geoinformatics, edited by Peter Atkinson, in *Encyclopedia of Life Support Systems* (EOLSS), Developed under the auspices of the UNESCO, Eolss Publishers, Oxford, UK, [http://www.eolss.net]
5	Goovaerts, P., Wobus, C., Jones, R., and M. Rissing. 2016. Geospatial estimation of the impact of Deepwater Horizon Oil Spill on plant oiling along the Louisiana shorelines. *Journal of Environmental Management*, 180(15): 264-271
6	Goovaerts, P. 2017. The drinking water contamination crisis in Flint: Modeling temporal trends of lead level since returning to Detroit water system. *Science of Total Environment*, 581-582: 66-79

7 Goovaerts, P. 2017. Monitoring the aftermath of Flint drinking water contamination crisis: Another case of sampling bias. *Science of the Total Environment*, 590-591: 139-153

8 Goovaerts, P. 2017 How geostatistics can help you find lead and galvanized water service lines: The case of Flint, MI. *Science of the Total Environment*, 599-600: 1552-1563

9 Goovaerts, P. 2019 Geostatistical prediction of water lead levels in Flint, Michigan: a multivariate approach. *Science of the Total Environment*, 647: 1294-1304

10 Goovaerts, P. 2018. Flint drinking water crisis: a first attempt to model geostatistically the space-time distribution of water lead levels. In: B.S.D. Sagar, Q. Cheng, F. Agterberg (Eds.) Springer *Handbook of Mathematical Geosciences: Fifty Years of IAMG*, Chapter 14, pages 255-275.

11 Abernethy, J., Anderson, C., Dai, C. et al., 2016. Flint water crisis: Data-driven risk assessment via residential water testing. arXiv preprint arXiv:1610.00580. https://arxiv.org/abs/1610.00580. (accessed May 9 2020)

12 Abokifa, A.A., Katz, L., and L. Sela. 2020. Spatiotemporal trends of recovery from lead contamination in Flint, MI as revealed by crowdsourced water sampling. *Water Research*, 171: 115442, 10.1016/j.watres.2019.115442

13 Nuckols, J., Ward, M., and L. Jarup. 2004. Using geographic information systems for exposure assessment in environmental epidemiology studies. *Environmental Health Perspectives*, 112: 1007–1115

14 National Research Council 2012. *Exposure Science in the 21st Century: A Vision and a Strategy*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13507

15 Wang, Z., Devine, H., Zhang, W. et al. 2014. Using a GIS and GIS-assisted water quality model to analyze the deterministic factors for Lead and Copper corrosion in drinking water

distribution systems. *Journal of Environmental Engineering*, 140, A4014004

16 Goovaerts, P., AvRuskin, G., Meliker, J., Slotnick, M., Jacquez, V, and J. Nriagu. 2004. Modeling uncertainty about pollutant concentration and human exposure using geostatistics and a space-time information system: Application to arsenic in groundwater of Southeast Michigan. In *Accuracy 2004*: Proceedings of the 6th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences

17 Cohen, J. 1960. A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20(1), 37–46

18 Flint Safe Drinking Water Task Force Recommendations on MDEQ's Draft Sentinel Site Selection. (February 2016). Retrieved from https://www.michigan.gov/documents/flintwater/MDEQ_Sentinel_Site_ Selection_ 514629_7.pdf on May 10, 2020.

19 VATECH_00212274

20 *Carthan et al. v. Snyder et al.*, 5:16-cv-10444-JEL-MKM, *Fourth Consolidated Amended Class Complaint for Injunctive and Declaratory Relief, Money Damages, and Jury Demand*, ECF No. 620-3, PageID.17802-18022 (E.D. Mich. Oct. 5, 2018).

BOOKS REFERENCED

Goovaerts, P. 1997. *Geostatistics for Natural Resources Evaluation*. Oxford Univ. Press, New-York, 483 p. 4th printing in June 2005. Reference textbook used in many universities, including the Ph.D. program in Geostatistics at Stanford University. 4th most cited book in the geostatistical literature

Montero, J.M., Fernandez-Aviles, G., and J. Mateu. 2015. *Spatial and spatio-temporal geostatistical modeling and kriging*. Wiley, New York

Fleiss, J.L. 1981. *Statistical Methods for Rates and Proportions* (2nd ed.). John Wiley: New-York